With compliments of the Secretary
Indian Tea Association

INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

IMPERIAL MYCOLOGICAL
6 APR. 1936
INSTITUTE

REPORT

BY

THE CHIEF SCIENTIFIC OFFICER
P. H. Carpenter, F.I.C., F.C.S.

On the Work of the Department for the Year 1934.

Calcutta:
PRINTED AT THE CATHOLIC ORPHAN PRESS
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On the Work of the Department for the year 1934

The health of the staff throughout the year has been normal.

Messrs. P. H. Carpenter and S. F. Benton proceeded on home-leave during the year.

Buildings.

Costs of repairs to buildings were kept to as low a figure as possible but it may be necessary to increase this amount in the following years in order to maintain the buildings in a proper state of repair.

Touring.

Owing to the shortage of staff systematic touring was impossible.

The following visits were made during the year.

Touring, 1934.

Month	P. H. Carpenter	H. R. Cooper	A. C. Tunstall	C. J. Harrison	S. F. Benton	W. Wight	M. Singha
January	Dooars and Terai	Calcutta	.....	.....	.....	.....	.....
February	Calcutta and	.....	.....	.....	Silchar	.....	Dooars
March	Delhi	.....	Darjeeling	.....	Dibrugarh	.....	.....
April	Calcutta	.....	.....	Tulsipara	Calcutta	.....	.....
May	HOME LEAVE	.....	.....	.....	HOME LEAVE	.....	.....
June		.....	.....	.....		.....	.....
July		.....	.....	.....		.....	.....
August		.....	.....	.....		.....	.....
September		.....	.....	.....		.....	.....
October		.....	Cachar Sylhet and Dooars	.....		.....	.....
November	Calcutta and Tezpore	Terai	.....	.....	.....	.....	.....
December	.....	.....	.....	Sibsagar	Calcutta	.....	Sibsagar

Correspondence. During the year 3,377 letters were received by the Department and 4,140 letters were despatched.

The total number of samples and specimens received during the year were :—

	Chemical Branch ...	1,386 (including samples from Borbhetta and Tocklai).
Specimens.	Entomological Branch ...	52
	Mycological Branch ...	1,252
	Bacteriological Branch ...	119
	Botanical Branch ...	19

Lecture Courses. During the year two series of Lecture Courses were held in the cold weather.

96 visitors came to Tocklai.

Rao Bahadur M. Vaidyanathan, Statistician to the Imperial Council of Agricultural Research, visited Tocklai in order to discuss statistical methods.

Experiments on Estates. The field experiments at Tulsipara have been maintained, and we have again received the results from the experiments conducted at Halem Tea Estate.

CHEMICAL.

The work of this Branch during 1934 has consisted mainly in carrying out manufacturing experiments in the Tocklai factory for the purpose of investigating the effect of various cultural factors on the quality of tea.

Routine work in connection with Soil Acidity and analysis of the nitrogen content of soils and manures, has been continued, and in addition weekly estimations have been made of nitrates in soil from plots at Borbhetta on which green crop experiments are being carried out. Two experiments on the effect of various phosphatic manures on green crops were made at Tocklai, and in the first experiment complete analyses of the nitrogen content of leaves, stems and roots of green crops from all plots under experiment were made.

The results of all the experiments are considered under the following heads :—

I. Manufacture, experiments. Effect of various treatments on the quality of tea.

- A. Effect of nitrogenous manures in various forms.
- B. Effect of phosphoric acid.
- C. Effect of potash.
- D. Effect of different forms of plucking.
- E. Influence of variety, "Jat".
- F. Effect of treating withering cloth with fireproofing solution.

II. Soil Acidity.

III. Effect of green crops on nitrate content of soils.

IV. Effect of Potash and Phosphoric acid manures on growth and nitrogen content of green crops.

Manufacture Experiments.

In each of the experiments conducted during 1934 on the effect of various cultural factors on the market value of tea, a design was followed which enables us to assess the effect of influencing factors outside the particular one which was being studied. In order to understand the reasons for employing this design, a knowledge of our method of manufacture is necessary.

The leaf samples were brought into the withering shed about midday and spread, in turn, on bamboo racks covered with cloth, which was always boiled each day before manufacture. Rolling started next morning at 4 a.m. in the hot weather experiments and at 6 a.m. during the cooler weather in October and November. Thus the leaf had a minimum of 15 hours wither. The leaf was spread on the withering chungs in the same order as that of rolling.

There are two rollers, designated East and West rollers. They are of the same type, but even when running at identical speeds and with apparently the same pressure, do not produce identical effect, *i.e.*, bruising and twisting action, on the leaf.

The East roller, on account of slightly larger clearance between box and table, allows considerably more leaf to escape and be ground up between the edge of the box and the table. This leaf is continually swept back, but the resultant effect is to cause more bruising and breaking up of the leaf.

The rolling system was :—1st roll of one hour, starting with 10 minutes no pressure and then alternatively 10 minutes pressure and 5 minutes no pressure. The leaf was then dropped, balls broken up by hand, and the leaf returned to the same roller. The time occupied between stopping the 1st roll and starting the second was 5 minutes.

The second roll was for ½ hour with alternatively 10 minutes pressure, and 5 minutes no pressure.

As the pressure cap is a wooden one about 20" square and 5" deep, and is not held down by any spring, the maximum pressure obtainable is not very great, small in fact, in comparison with that of the larger types of roller used in factories.

The dryer is a Single Tilting Tray Sirocco, divided into two equal portions so that two samples can be fired simultaneously.

Eight different treatments were under trial in all experiments except one, the 'jat' experiment, where there were only 6 different 'jats' under trial. Now supposing eight samples of leaf which had had identical treatment are to be manufactured, the most convenient way is to roll, ferment and fire them in pairs, one of each pair in the East and one in the West roller. There would thus be $\overline{4}$ pairs of rolls, at 95 minutes intervals (allowing 90 minutes for each roll and 5 minutes for filling the roller).

One could therefore not expect to get eight identical teas from this manufacture. Firstly, the $\overline{4}$ teas rolled in the East roller might differ considerably from those rolled in the West roller, and secondly the four pairs of teas might differ according to the order in which they were rolled, since the second pair get 95 minutes, the third 190 minutes and the fourth pair 285 minutes, longer withering than the first pair, and moreover, the later rolled teas are rolled and fermented usually at higher temperatures than those earlier rolled.

If, as in the case of our experiments, the eight samples of leaf are from plots differing in manuring, plucking, or some other way, the relative values of the resulting teas could not be expected to represent truly this treatment, but should be affected by the order in which the samples were rolled, or by the roller used.

When treatment is such as to produce very wide differences in the teas, as in the 'jat' or the plucking experiment, the effect of a difference of 3 or 4 hours in withering, or of the different actions of the rollers, is to a great extent masked. When however, the treatment produces very much smaller differences as in manuring experiments, the effect of the rollers and order of rolling shows up.

It is impossible to eliminate these outside factors, nor is it necessary to do so. By manufacturing the samples a sufficient number of times we can arrange for all the samples to occupy every position in the order of manufacture the same number of times and to be rolled an equal number of times in each roller. If the eight samples are all manufactured on eight occasions, each sample can be rolled 4 times in the East and 4 in the West roller; each sample can also occupy on two occasions, each of the first, second, third and fourth positions in order of rolling.

This is best seen in the diagram Table I. The arrangement is that known as the Latin Square.

TABLE I.

Arrangement of Plucking Experiments.

Order of manufacture.	Roller.	DATES OF MANUFACTURE.							
		10th Aug.	17th Aug.	24th Aug.	31st Aug.	7th Sept.	14th Sept.	21st Sept.	28th Sept.
1st. ...	East ...	coarse	Fine 3	medium	superfine	Fine 1	banjhis	very coarse	Fine 2
	West ...	Fine 1	coarse	superfine	banjhis	Fine 2	medium	Fine 3	very coarse
2nd. ...	East ...	medium	superfine	Fine 2	Fine 3	coarse	very coarse	banjhis	Fine 1
	West ...	banjhis	Fine 2	very coarse	medium	Fine 3	superfine	Fine 1	coarse
3rd. ...	East ...	Fine 2	banjhis	Fine 3	coarse	very coarse	Fine 1	medium	superfine
	West ...	Fine 3	very coarse	banjhis	Fine 1	superfine	Fine 2	coarse	medium
4th. ...	East ...	very coarse	medium	Fine 1	Fine 2	banjhis	coarse	superfine	Fine 3
	West ...	superfine	Fine 1	coarse	very coarse	medium	Fine 3	Fine 2	banjhis

After the tea has been fired, it is cut by passing it through a Savage cutter with ½" cells and then through the same cutter with ¼" cells. The dust and very small "fannings" are sifted out and comprise about 7% of the total bulk. The very coarse leaf, comprising about 6% of the total bulk is also sifted out. Thus the tea from which samples are taken for tasting and valuations and for analyses, comprises at least 85% of the original leaf manufactured.

In the case of all except the plucking experiment, the percentages of dust and of coarse tea were identical for all samples on any particular manufacture. In the case of the plucking experiment, it was expected that there would be much more coarse grade tea from the coarser plucked leaf and for this reason valuations were obtained both for the main bulk (labelled B.P.) and for the very coarse tea (labelled Souchong). Actually, the variations in percentages were much less than anticipated, and average valuations are very much the same whether or not allowance is made for the slight variations in percentages of coarse and fine tea.

The tasters' valuations on the complete set of 64 samples can be subjected to the "Analysis of Variance" (Fisher), which is a mathematical method of obtaining the effect on valuations, or variance, due to the treatments under trial, due to each of the other extraneous factors, and the residual or error variance which is that portion of the variance due to factors either not known, or not accounted for. From this error variance, it can be calculated which differences are really significant and which may be due to chance only. In the following account of experimental results, the "significant differences" are calculated so that there is a 20 to 1 chance on any difference in average valuation between any two samples which is greater than the significant difference, being really due to the difference in treatment and not to chance.

The whole method of calculating the variances and the significant difference is illustrated by an example taken from the plucking experiment, the latin square lay-out of which was given above.

Table II.

Valuation corresponding to samples as in Table I.

Order of manufacture.	Roller.	Taster L's valuations in pence.								Average valuations.
		10/8.	17/8.	24/8.	31/8.	7/9.	14/9.	21/9.	9 8/9.	
1. ...	E. ...	10¾	11¾	11½	12½	11½	10¾	11	12	11·47d.
	W. ...	12¼	11½	12½	10¾	13	12¼	12½	11¼	12·03d.
2. ...	E. ...	11¾	12	10¾	12½	12½	11½	10½	12½	11·75d.
	W. ...	10½	12½	10½	12	13½	13¼	12¾	11¾	12·09d.
3. ...	E. ...	12	10¼	12	11½	13¼	13½	12¼	11¾	12·06d.
	W. ...	11	10¼	10¼	11¼	11¾	11¾	11¼	11½	11·12d.
4. ...	E. ...	10¼	10¾	12¼	11¼	11¼	12½	11¾	12¾	11·66d.
	W. ...	11¼	11¼	11¼	10¾	12	13	11¼	11¼	11·50d.
Average for each day's samples.		11·25	11·28	11·37	11·56	12·34	12·31	11·72	11·84	11·71d.

The average of all 64 valuations in 11.71*d.* To simplify the arithmetic, the difference between each valuation and a rough average (called the "crude mean") of 11¾*d.* is used for working out the results. The table below is therefore the same as Table II, except that valuations are written as differences from 11¾*d.* in farthings.

Table III.

Deviations from crude mean 11¾d. in farthings.

Order of manufacture.	Roller.	Dates of manufacture.								Totals.
		10/8.	17/8.	24/8.	31/8.	7/9.	14/9.	21/9.	28/9.	
1. ...	E. ...	−4	0	−1	3	−1	−4	−3	1	−9
	W. ...	2	−1	3	−4	5	2	4	−2	9
2. ...	E. ...	0	1	−4	3	3	−1	−5	3	0
	W. ...	−5	3	−5	1	7	6	4	0	11
3. ...	E. ...	1	−6	1	−1	6	7	2	0	10
	W. ...	−3	−6	−6	−2	0	0	−2	−1	−20
4. ...	E. ...	−5	−4	2	−2	−2	3	1	4	−3
	W. ...	−2	−2	−2	−4	1	5	−2	−2	−8
Date Totals ...		−16	−15	−12	−6	19	18	−1	3	−10

The correction for taking the crude mean of 11.75*d.*, instead of the exact mean of 11.71*d.*, is given by the square of the grand total -10, divided by the total number of samples, *i.e.*, $\frac{10^2}{64} = 1.56$. This correction must be deducted from all variances.

The total variance is given by the sum of the squares of all the individual differences from crude mean, less the correction.

Total variance $= 722 - 1.56 = 720.44$.

Treatment variance. By reference to Table I. and Table III., the total deviation from the crude mean can be obtained for each treatment, *e.g.*, for superfine plucking, the deviations are as follows :—

Date of manufacture.								Total
10-8	17-8	24-8	31-8	7-9	14-9	21-9	28-9	
-2	-1	3	3	0	6	1	0	12

Similarly for each of the other treatments giving the following :—

TABLE IV.

Treatments totals.

Style of plucking.	*Deviations from crude mean.*
Superfine	12
Fine 1	21
Fine 2	2
Fine 3	13
Medium	0
Coarse	4
Vary coarse	−20
Banjhi	−34

The treatment variance is given by the sum of the squares of the treatment deviations in the above table divided by the number of repeats of each treatment (*i.e.*, 8), and less the correction.

$$\text{Treatment variance} = \frac{2330}{8} - 1{\cdot}56 = 289{\cdot}69.$$

Order of manufacture variance. The variance due to order of manufacture is obtained from the totals in the last column of Table III.

The deviations for each order of manufacture are :—

	Rolled at	Total deviations
1st pair	4·00 a.m.	0
2nd ,,	5·35 a.m.	11
3rd ,,	7·40 a.m.	-10
4th ,,	8·45 a.m.	-11

The variance due to order of manufacture.

$$= \frac{\text{sum of squares of deviations}}{\text{number of samples comprising each pair}} \text{ minus the correction.}$$

$$\text{Order of manufacture variance} = \frac{342}{16} - 1{\cdot}56 = 19{\cdot}81.$$

Date Variance. There are differences in average valuations from week to week, depending partly on the relative intrinsic values of the eight sets of samples, and also on the state of the market from week to week.

This variance is given by the sum of the squares of the week to week deviation totals, divided by the number of teas valued each week (8) less the correction.

$$\text{Thus date variance} = \frac{1356}{8} - 1{\cdot}56 = 167{\cdot}94.$$

Analysis of variance.

	Variance	degrees of freedom	mean square
treatment	289·69	7	41·384
date	167·94	7	23·991
order or manufacture	19·81	3	6·603
roller action	0·64	1	0·640
residual (or error)	242·36	45	5·39

The residual variance is the difference between the sum of all the variances and the total variance.

The degrees of freedom are the number of comparisons possible, that is in each case, one less than the number of individuals concerned, *e.g.*, as there are 64 samples, each can be compared with 63 others, hence the total number of degrees of freedom is 63. The treatment variance is that of 8 treatments hence for treatment there are 7 degrees of freedom; so on.

The mean square of the variance is the variance divided by the number of degrees of freedom.

In order to test whether any variance is a significant one, reference must be made to what is known as the "Z" test. The mean square of any particular variance must be greater than the residual variance by an amount which depends on the degrees of freedom both for the particular variance and for the residual variance; this amount can be found from statistical tables.

In the above example the mean squares for treatment and date variances must be about 2¼ times the residual mean square for a 20 to 1 chance of significance. Actually both variances are much more than this and are therefore significant.

The order of manufacture variance must be over 2¾ times, and the roller action variance 4 times the residual variance. As this is not the case neither of these variances is significant.

The square root of the mean square for error gives the "standard error", which in this case is $\sqrt{5.390} = 2.32$. This means, that, judged by the form shown during this experiment, any single tasting is liable to an error not exceeding 2.32 farthings.

A possibility of error of about ½*d.* seems high on this market even on a single tasting: but it must be remembered

that this estimate of error includes all sources of error not allowed for in the analysis of variance, including sampling errors not only at Tocklai but in the selection of a weighment from the sample tin, and that although we can allow for the average differance between, *e.g.*, rolling at 4 a.m., compared with rolling at 8-45 a.m., we know that this difference in time of rolling cannot make the same difference in quality every day.

The standard error of a difference between any two tastings is $\sqrt{2} \times 2.32$ or 3.28 farthings. Hence a comparison between two single tastings under these conditions has little significance. We have however to compare averages of a large number of tastings.

If the Z test is first passed, then the significant difference of the date or treatment totals is given by the expression

$$t \times \sqrt{2} \times \sqrt{\text{mean square of residual variance} \times \text{No. of samples comprising the totals.}}$$

where "t" depends on the degrees of freedom of residual variance and on the odds on the significance required.

For 46 degrees of freedom and odds of 20 to 1 on significance $t = 2.012$.

Thus the significant difference $= 2{\cdot}012 \times \sqrt{2} \times \sqrt{5{\cdot}39 \times 8} =$ 18.67 (or 8.048 × standard error 2.32).

Comparing the deviation totals of the various treatments (Table IV) any difference between any two of these totals which is greater than 18.67 indicates that the odds are at least 20 to 1 on the difference, whatever it is, being really due to the difference in treatment and not to chance.

The average valuations in pence, of the different treatments is obtained from the Table IV. by dividing by 4 (to bring farthings to pence) and again dividing by eight (to get the average of the eight valuations of which the figures are totals) and adding the crude mean 11¾*d*.

The following average valuations for treatment are obtained :—

Plucking treatment.	*Average valuations in pence per pound.*
No. 1. Superfine	... 12.125*d.*
2. Fine 1	... 12.407*d.*
3. Fine 2	... 11.813*d.*
4. Fine 3	... 12.156*d.*
5. Medium	... 11.750*d.*
6. Coarse	... 11.625*d.*
7. Very coarse	... 11.125*d.*
8. Banjhi	... 10.688*d.*

The significant difference in pence $= \frac{18{\cdot}67}{4 \times 8} = .584d.$ The highest valuation is that of Fine 1, 12.407*d.* Any valuation of 11.823 or above must be considered to be equal to 12.407 within experimental error.

Plucking treatments 1, 2 and 4 must therefore be concluded to give equally good teas.

Fine 1, is significantly better than Medium, or any of the coarse pluckings. All four fine pluckings are significantly better than the very coarse or *banjhi* pluckings.

In a similar way the average valuations for each date of manufacture are obtained and the significant difference is the same as that for treatment averages, there being the same number of treatments as there are repeats of the manufacture.

Date of manufacture	August				September			
	10th.	17th.	24th.	31st.	7th.	14th.	21st.	28th.
Average valuation (in pence)	11·250	11·281	11·375	11·563	12·344	12·313	11·719	11·844

The average valuations for order of manufacture are :—

1st.	...	11.750*d.*
2nd.	...	11.922*d.*
3rd.	...	11.594*d.*
4th.	...	11.578*d.*

There is no significant difference between these averages, that is, the order of manufacture has not affected valuations in this experiment.

The average valuations for the two rollers are :—

East roller	...	11.734*d.*
West roller	...	11.687*d.*

There is no significant difference between these averages, hence in these experiments the two rollers were giving teas of practically equal values.

In the experiments described below, all results were worked out exactly as in the above example. The averages only, for each taster are given.

When the results of two or more tasters are combined, there will be a much smaller significant difference for the average results than any of the significant differences for each individual taster's average, if there is reasonably good agreement between the tasters.

A. EFFECT OF NITROGEN IN DIFFERENT FORMS.

The leaf for this experiment was obtained from two adjoining blocks of tea at Borbhetta. Both were planted in 1921 from the same nursery of Tingamira (light leaf Assam) variety. One block, on which the effects of various concentrated nitrogenous manures are being compared, was medium pruned at 18″, in 1924, while the other block, devoted to comparison of the effects of various quantities of cattle manure on yield, was collar pruned at the same time, and the cattle manured block has always been slightly the better since planting in 1921. Thus although check

plots of both blocks have had identical treatment since 1924, they cannot, in view of the different pruning and slightly different soil be assumed without proof to be giving the same quality of leaf even at the present time. For this reason the unmanured check plots of each block were included in the experiment.

Eight samples of leaf were manufactued on each of eight occasions during June, July, and again on eight occasions during October, November, and December.

The manurial treatments of the plots from which the eight samples of leaf were taken, and their yields in 1934, were as follows :—

		mds. tea	
1.	Unmanured "A" ...	6.58	from the block which was medium pruned in 1923, and since top pruned.
2.	Sulphate of ammonia ...	11.61	
3.	Calcium cyanamide ...	11.15	
4.	Oilcake ...	10.07	
5.	Blood meal ...	11.05	
6.	Horn meal ...	11.26	
7.	Unmanured "B" ...	7.67	from the block which was collar pruned in 1923, and top pruned since.
8.	5 tons cattle manure ...	10.33	

These treatments with the exception of No. 8 have now been applied annually for the last 2 years in quantities to supply 60 lbs. nitrogen per acre per annum. The cattle manure application has been made three times in the last four years.

The results of the experiment are considered first for the second flush period, in which four tasters in India gave complete valuations, while incomplete results were obtained from 3 London tasters : secondly for the Autumnal period, when four sets of valuations were obtained from tasters in India and a like number from London.

1. *Valuations for "second flush" period.*

The average valuations of each of the four tasters in India, and the average of all four together, is given below :—

Kind of manure.	Valuations in annas and pies.				Average of all 4 tasters.
	A	B	C	D	
No manure A. ...	11-10·0	11-10·9	10-9·3	11-2·6	11-5·2
No manure B. ...	11- 9·0	11-10·5	10-7·7	11-0·1	11-3·8
Oilcake	12- 2·5	11- 8·5	10-9·4	11-2·3	11-5·8
Blood meal ...	11-10·0	11-11·1	10-9·4	11-3·0	11-5·6
Horn meal ...	11- 8·0	11- 9·4	10-8·9	11-5·2	11-4·9
Cattle manure ...	12- 0·0	11-11·6	10-8·9	11-1·3	11-5·4
Sulphate of ammonia...	12- 1·0	11-10·9	10-8·6	11-1·4	11-5·5
Calcium cyanamide ...	11- 6·0	11- 9·6	10-8·7	11-1·6	11-3·5
Average ...	11-10·31	11-10·31	10-8·86	11-2·19	11-4·96

The Z test shows that such differences as are shown by any of the four tasters in the above table, are not significant, nor are there any significant differences in the average valuations in the last column.

Variances due to date of manufacture, order of manufacture, roller action and tasters, all pass the requirements of the Z test. All differences therefore, in valuations due to these factors, which exceed their calculated significant differences, will be significant.

The average valuations of the London tasters are as follows :—

Kind of manure.	Valuations in shillings and pence.			Average.
	H.	J.	K.	
No manure A. ...	1-2·57	1-0·79	1-2·07	1-1·81
No manure B. ...	1-2·50	1-1·50	1-2·14	1-2·05
Oilcake	1-3·28	1-1·25	1-2·64	1-2·40
Blood meal ...	1-3·11	1-1·25	1-2·68	1-2·35
Horn meal ...	1-3·03	1-1·25	1-2·21	1-2·17
Cattle manure ...	1-2·25	1-0·75	1-2·14	1-1·71
Sulphate of ammonia ...	1-3·11	1-1·86	1-2·50	1-2·49
Calcium cyanamide ...	1-3·50	1-1·54	1-2·79	1-2·61
Average ...	1-2·84	1-2·84	1-2·40	1-2·20

Since reports on only seven out of the eight sets of teas were received from these tasters, the results cannot be submitted to the analysis of variance in its complete form. No variance due to order of manufacture or roller action can be determined.

There is certainly no indication that unmanured teas are preferable to the manured teas, or that the teas manured with organic manures are preferable to those manured with inorganic manures.

2. *Valuations for the autumnal period.*

The averages of the five tasters in India who reported on the teas are given below :—

Kind of manure.	Valuations in annas and pies.					Average.
	A.	C.	E.	F.	G.	
No manure A.	9-9·37	10- 9·00	11-7·12	10- 0·87	10-3·94	10-6·07
No manure B.	9-6·25	10-10·25	11-6·37	10- 1·00	10-2·19	10-5·20
Oilcake ...	9-9·12	10- 6·75	11-6·00	10- 1·00	10-1·94	10-4·99
Blood meal...	9-8·37	11- 2·00	11-6·50	10- 1·50	10-3·81	10-6·85
Horn meal ..	9-4·87	10- 4·44	11-5·62	10- 0·37	10-2·00	10-3·45
Cattle manure	9-7·50	10- 6·00	11-6·37	0-11·12	10-3·56	10-4·53
Sulphate of ammonia	9-5·37	10- 6·70	11-5·12	10- 1·00	10-2·50	10-4·30
Calcium cyanamide ...	9-4·87	11- 0·00	11-5·00	10- 0·37	10-4·12	10-5·27
Average ...	9-6·96	10- 8·80	11-6·11	10- 0·65	10-3·00	10-5·08

The Z test shows no significance in treatment differences, either for individual tasters or for the average of the 5 tasters.

The London tasters' valuations for the same teas are :—

Kind of manure.	Valuations in shillings and pence.				Average.
	H	J	K	L	
No manure A. ...	1-1·89	1-1·03	1-0·63	1- 1·03	1-1·17
No manure B. ...	1-1·79	1-1·06	1-0·81	1- 0·47	1-1·03
Oilcake	1-2·25	1-0·97	1-0·97	1- 0·41	1-1·15
Blood meal ...	1-1·57	1-0·66	1-0·72	1- 0·34	1-0·82
Horn meal ...	1-2·43	1-0·97	1-0·97	1- 0·22	1-1·15
Cattle manure ...	1-0·93	1-0·69	1-0·56	0-11·81	1-0·50
Sulphate of ammonia ...	1-2·18	1-0·94	1-0·97	1- 0·34	1-1·11
Calcium cyanamide ...	1-2·93	1-1·16	1-0·94	1- 0·53	1-1·39
Average	1-1 98	1-0·93	1-0·82	1- 0·39	1-1·04

Taster H values only 7 of the 8 sets of samples and his figures are averages of 7 valuations in each case.

The other 3 tasters valued all 8 sets and their figures are averages of all eight.

The average values of tasters J, K and L, based on complete valuations, are as follows :—

	s. d.
No manure A ...	1-0.90
No manure B ...	1-0.78
Oilcake ...	1-0.78
Blood meal ...	1-0.57
Horn meal ...	1-0.72
Cattle manure ...	1-0.35
Sulphate of ammonia ...	1-0.75
Calcium cyanamide ...	1-0.88

There are no significant differences when all available data are taken into account, *i.e.*, variance for date, rollers, order of manufacture, the variations between the tasters' individual valuations of the same individual samples being so great.

Analysis of teas manured with different forms of nitrogenous manures.

Complete analysis of tannin, caffeine and soluble solids were made on five minute infusions of the 8 sets of 8 teas from the above experiment. Averages of eight analyses are given below :—

	Tannin. %	Soluble solids. %	Caffeine. %
No manure A. ...	6·49	25·21	2·50
No manure B. ...	6·46	25·43	2·67
Oilcake	6·77	25·85	2·55
Blood meal	6·61	25·64	2·72
Horn meal	6·65	25·82	2·61
Cattle manure	6 53	25·80	2·63
Sulphate of ammonia ...	6·72	25·83	2·73
Calcium cyanamide ...	6·78	25·83	2·69
Significant difference ...	0·233	not significant	not significant

Manuring has affected neither caffiene content nor total soluble solids.

Calcium cyanamide and oilcake give teas with significantly higher tannin content than either unmanured tea or the cattle manured tea. Sulphate of ammonia shows increased tannin contents as compared with no manure on the verge of significance.

Since tannin makes for other good qualities apart from flavour, the indications therefore are that manuring has improved quality very slightly.

B. & C. EFFECT OF POTASH AND PHOSPHORIC ACID IN VARYING COMBINATIONS AND QUANTITIES.

Two experiments were carried out in this connection, one occupied the period June and July and was followed by a second covering the period August and September.

In both cases the plots from which the leaf was obtained were the Tingamira plots devoted to the effect of potash and phosphoric acid in varying quantities. The experiment comprises 16 treatments, each repeated 8 times.

1. *Varying quantities of phosphoric acid with and without potash.*

Leaf from eight of the plot-sets was manufactured weekly on eight successive occasions during June and July. The manure mixtures applied to these eight series were such as to supply 40 lbs. nitrogen per acre (as sulphate of ammonia), together with quantities of superphosphate to supply phosphoric acid varying from 0 to 60 lbs. per acre, both in the absence of potash and with sulphate of potash to supply 30 lbs. potash per acre (see table below).

Plot-set.	Manure to supply lbs. per acre.		
	Nitrogen.	Phosphoric acid.	Potash.
2	40	0	0
5	40	15	0
9	40	30	0
13	40	60	0
3	40	0	30
7	40	15	30
11	40	30	30
15	40	60	30

The design of the experiment was similar to that of the experiments described previously in this report, except that the leaf from the four series getting no potash were manufactured on each occasion before the four getting the dose of potash. Thus the experiment is really resolved into two separate experiments.

The two experiments were each arranged on a double Latin square plan so that each sample, during the eight occasions of manufacture, occupied every position in time of manufacture four times (twice in June and twice in July), and was rolled an equal number of times in each roller (also twice each month). The plan given below illustrates the arrangement actually

adopted; the numbers indicating the manurial treatment detailed in the previous table.

Set. I. No potash: increasing phosphoric acid.

Date of manufacture.	Order of manufacture and roller.			
	First.		Second.	
	East roller.	West roller.	East roller.	West roller.
June 5th. ...	9	5	13	2
„ 12th. ...	13	9	2	5
„ 19th. ...	5	2	9	13
„ 26th. ...	2	13	5	9
July 3rd. ...	5	2	9	13
„ 10th. ...	13	5	2	9
„ 17th. ...	2	9	13	5
„ 24th. ...	9	13	5	2

Set II. 30 lbs. potash: increasing phosphoric acid.

Date of manufacture.	Order of manufacture and roller.			
	First		Second.	
	East roller.	West roller.	East roller.	West roller.
June 5th. ...	7	15	11	3
„ 12th. ...	15	7	3	11
„ 19th. ...	11	3	15	7
„ 26th. ...	3	11	7	15
July 3rd. ...	7	3	11	15
„ 10th. ...	15	7	3	11
„ 17th. ...	3	11	15	7
„ 24th. ...	11	15	7	3

All eight sets of teas were submitted to four Calcutta tasters. All except the first set were also sent to three London tasters. The average valuations are given below.

Tasters in India.

lbs. per acre manure.			Valuations in annas and pies.				Average.
N.	P.	K.	A	B	C	D	
40	0	0	11-10·87	11-10·25	10-10·00	11-5·62	11-6·18
40	15	0	12- 1·87	11-11·12	10- 9·00	11-5·62	11-6 90
40	30	0	12- 4·50	11-11·25	10- 9·82	11-5·62	11-7·80
40	60	0	12- 0·00	12- 0·35	10- 9·88	11-3·27	11-6·38
Average ...			12- 1·31	11-11·25	10- 9·68	11-5·03	11-6·81
40	0	30	12-6·75	11-10·50	10-10·50	11-4·12	11-7·97
40	15	30	12-0·00	12- 2·25	10-10·19	11-3·37	11-6·95
40	30	30	12-7·12	12- 0·00	10-10·88	11-2·62	11-8·15
40	60	30	12-0·75	11- 9·37	10-10·94	11-0·00	11-5·26
Average ...			12-3·65	11-11·53	10-10·63	11-2·53	11-7·08

In no case does the treatment variance pass the Z test indicating that there are no significant differences in any of the sets of valuations, either for individual tasters or for the averages of all four tasters.

London Tasters.

manure lbs. per acre.			Valuations in shillings and pence			
N.	P.	K.	H.	J.	K.	average
0	0	0	1-3·25	1-1·21	1-2·07	1-2·18
40	15	0	1-3·56	1-1·43	1-1·80	1-2·26
40	30	0	1-3·19	1-1·86	1-1·93	1-2·33
40	60	0	1-3·81	1-1·68	1-2·14	1-2·54
Average ...			1-3·45	1-1·54	1-1·99	1-2·33
40	0	30	1-2·97	1-1·46	1-1·80	1-2·08
40	15	30	1-2·50	1-1·04	1-2·14	1-1·89
40	30	30	1-2·56	1-1·04	1-1·71	1-1·77
40	60	30	1-2·37	1-0·71	1-1·50	1-1·53
Average ...			1-2·60	1-1·06	1-1·79	1-1·83

There are no significant differences in the above valuations except in the case of Taster H, for the teas, manured with varying quantities of phosphoric acid with no potash. His significant difference in this case is 0.38*d*. and he finds a significant difference in favour of the teas from the manuring with 40 lbs. nitrogen and 60 lbs. phosphoric acid, as compared with the teas from 40 lbs. nitrogen and either no phosphoric acid or 30 lbs. phosphoric acid.

2. *Varying quantities of potash with and without phosphoric acid.*

This experiment occupied the period from the beginning of August to the middle of September. Leaf from the following series of plots of the Tingamira experiment was manufactured on eight occasions.

Plot-set.	Manuring		
	Nitrogen	Phosphoric acid	Potash
1	0	0	0
2	40	0	0
3	40	0	30
4	40	0	60
9	40	30	0
10	40	30	15
11	40	30	30
12	40	30	60

As in previous experiments the order of manufacture was arranged in Latin square form, each series occupying a different position in the order of manufacture on each of the eight occasions.

The average India and London valuations are given below :—

lbs. per acre			India annas per lbs.		Average India.	London. price per lbs.				Average London.
N.	P.	K.	A	C		H	J	K	L	
0	0	0	10- 2·00	9-8·12	9-11·06	14·59	12·69	13·34	11·91	13·13
40	0	0	10- 0·25	9-7·62	9- 9·93	14·81	12·56	13·31	11·81	13·12
40	0	30	9-10·75	9-8·25	9- 9·50	14·56	13·06	12·97	11·87	13·11
40	0	60	10- 9·25	9-7·37	9- 9·81	14·06	12·75	12·97	11·47	12·81
40	30	0	10- 1·50	9-8·00	9-10·75	14·50	13·09	13·38	12·56	13·38
40	30	15	10- 1·12	9-7·87	9-10·50	14·72	13·44	12·84	11·60	13·15
40	30	30	10- 0·50	9-8·19	9-10·35	14·72	12·87	13·00	12·00	13·15
40	30	60	10- 1·62	9-7·62	9-10·62	14·09	12·59	13·00	11·37	12·76
Average			10- 0·75	9-7·88	9-10·22	14·51	12·88	13·10	11·82	13·06

None of the tasters in India nor tasters H, J or K in London make any significant differences due to manurial treatment. The combined averages of the tasters A and C also do not show significant differences.

Taster L does give significant results. The significant difference required is 0.64*d*. which makes the teas manured with 40 lbs. nitrogen, 30 lbs. phosphoric acid and no potash significantly better than any except the teas manured with 40 lbs. nitrogen and 30 lbs. each of phosphoric acid and potash. The combined results of all four London tasters show significant differences (S.D.). The S.D. required is 0.35*d*. Referring to the average valuations for the London tasters, the following manurial treatments give almost identical valuations :—

	Nitrogen.	*Phosphoric acid.*	*Potash.*
(*a*)	0	0	0
(*b*)	40	0	0
(*c*)	40	0	60
(*f*)	40	30	15
(*g*)	40	30	30

It is interesting that the unmanured samples are not preferred, although the actual yield given by the unmanured plots is only about ⅔rd. that of manured plots. Both samples with

heavy doses of potash (60 lbs. per acre), get valuations either significantly worse than the rest, or very close to significance.

As in the 1933 experiments, the effect of phosphoric acid without potash is not on a 20 to 1 level of significance, but again the difference in favour of phosphoric acid is suggestive.

All four tasters place the heavy potash teas last and this at any rate seems definite, and again agrees with the 1933 results.

The Potash and Phosphoric acid contents of teas manured with varying quantities of potash, with and without phosphoric acid as follows.

Manure lbs. per acre.			Average percentage on dry tea.		Ratio of potash to phosphoric acid.
N.	P.	K.	phosphoric acid.	potash.	
0	0	0	·919	2·58	2·82
40	0	0	·889	2·48	2·78
40	0	30	·899	2·54	2·83
40	0	60	·908	2·62	2·89
40	30	0	.940	2·45	2·61
40	30	15	·937	2·50	2·67
40	30	30	·939	2·57	2·74
40	30	60	·935	2·62	2·80
Significant difference			·018	0·064	*nil.*

The analysis results may be summarised as follows :—

(*a*) Manuring with nitrogen only has produced a tea containing significantly less phosphoric acid and potash than unmanured tea.

(*b*) The effect of using phosphoric acid as manure is to raise the phosphoric acid content, but the potash content is not changed.

(*c*) The effect of potash manures on the phosphoric acid content is negligible, but on the potash content, the result is a significant increase.

D. EFFECT DIFFERENT STYLES OF PLUCKING.

The leaf from eight different styles of plucking was manufactured on eight occasions in August and September.

A block of dark leaf variety tea planted in 1928, and giving about 8 mds. per acre at the present time was divided into 56 plots. Up to the end of July, all plots were plucked alike and yields recorded. The area was split into 8 sets of 7 plots in each set and on 28th July and on the same day for 8 subsequent weeks the 8 different styles of plucking given below were done at weekly intervals.

Description of plucking.	Plucking instructions.	How broken back.	Yields for August and September mds. tea per acre.		
			Growing shoots.	Banjhis shoots	Total.
1. Superfine ...	All shoots of one leaf and two leaves to be plucked (Double banjhis plucked and weighed separately and not included) ...	To janam ...	2·26	0·43	2·69
2. Fine 1 ...	Very large shoots of one leaf and a bud and all single banjhis plucked ...	To original plucking level ...	2·63	...	2·63
3. Fine 2 ..	As for Fine 1	To janam ...	2·63	...	2·63
4. Fine 3 ...	As for Fine 1	Not broken back at all	2·62	...	2·62
5. Medium ...	Shoots of two leaves plucked (Double banjhis plucked and weighed separately) ...	To janam ...	2·35	0·67	3·22
6. Coarse ...	All shoots of two or more leaves and all banjhis plucked	Not necessary	3·83	...	3·83
7. Very coarse...	All shoots of three leaves plucked (Double banjhis plucked and weighed separately)	Not necessary	3·76	1·02	4·78
8. Double banjhis	The double banjhis af superfine, medium, and very coarse plucking were combined	.....	...	...	...

On every occasion of manufacture, an analysis of the percentage by weight and by numbers, of one and bud, 2 and bud, 3 or more leaves and bud, single and double *banjhis* in each of the leaf samples for manufacture, was made. From these figures the average weights of shoots of varying degree of fineness, was calculated.

After withering, samples of leaf were taken for moisture determination, and after manufacture analyses of the tannin, caffeine and total solids content of 5 minutes infusions of the finer grade was made on each tea.

In sorting, two grades were made, *viz.*, finer grade labelled B. P. consisting of 70-80% of the total bulk, and a coarse grade, labelled Souchong, consisting of 15-25%. The remainder was a mixture of dust and small fannings and amounted to about 6%.

Reports and valuations were obtained on the B. P. and the Souchong.

The table below gives the average results of the leaf counts and weights obtained on each of the eight samples.

From this table it can be seen that the plucking orders were reasonably well carried out. The superfine plucking consists almost entirely of shoots of one or two leaves and a bud. Counting erred on the strict side. Shoots with two fully opened leaves and one just uncurled from the bud were counted as 3 and a bud. Thus in many cases shoots counted as three and a bud, were probably only 2 and a bud at the time they were plucked. Where there was doubt as to a shoot being *banjhi* or not, it was regarded as being *banjhi*.

The table of average weight of shoots is interesting. The superfine plucking gives smaller shoots of every type than do the freer styles of plucking.

Two and bud shoots from the very coarse plucking, and 3 and bud shoots from either ordinary or very coarse plucking, are larger than those of the finer styles.

The double *banjhis* from coarse plucking are bigger than those from the finer pluckings.

There is no appreciable difference between the sizes of any of the shoots from the "fine" or "medium" pluckings.

Average percentage weight of shoots of different kinds in large samples.

	1 Super-fine.	2 Fine 1.	3 Fine 2.	4 Fine 3.	5 Med-ium.	6 Coarse	7 Very coarse.	8 Double banjhi.
One and bud	18·2	8·2	6·5	5·7	2·5	1·1	0·1	.....
Two and a bud	79·2	78·9	83·7	84·6	88·0	47·3	5·0	.....
Three and a bud	1·7	5·2	3·6	3·1	6·0	39·8	93·2	.....
Single banjhi	0·2	3·1	2·5	3·9	0·5	0·4	.....	.....
Double banjhi	0·7	4·6	3·7	2·7	2·0	11·4	1·7	soft 23·7 hard 76·3

Average percentage numbers of shoots of different kinds found in large samples.

One and bud	28·7	12·0	10·1	7·8	4·3	2·5	0·7	.....
Two and bud	68·6	73·9	76·0	80·0	87·8	55·6	6·7	.....
Three and bud	1·2	4·1	2·8	2·6	4·4	28·8	91·0	.....
Single banjhi	0·5	4·9	5·9	6·0	0·9	0·6	.....	.....
Double banjhi	1·0	5·0	5·2	3·6	2·6	12·5	1	soft 26·2 hard 73·8

Average weight of one shoot in grams.

One leaf and bud	0·16	0·19	0·21	0·21	0·20	0·19	0·18	.....
Two leaves and bud	0·32	0·33	0·37	0·37	0·37	0·37	0·57	.....
Three " " "	0·40	0·42	0·42	0·48	0·48	0·60	0·81	.....
Single banjhi	0·09	0·14	0·15	0·16	0·21	0·22	.....	.....
Double banjhi	0·17	0·24	0·23	0·24	0·27	0·42	0·68	soft 0·37 hard 0·47
Average of shoots plucked	0·24	0·28	0·32	0·33	0·34	0·40	0·77	0·46

Tasters Report on the Teas.

The following are the complete valuations of three tasters in India and four in London, on teas made during August and September from the eight different styles of plucking, described above.

Valuation on Broken Pekoes.

Style of plucking.	India (annas and pies).				London (pence).				
	A	C	E	India Average.	H	J	K	L	London Average.
Superfine	10- 1·75	9- 2·00	10- 3·37	9-10·37	11·63	13·50	13·37	12·12	12·65
Fine (1)	9- 9·38	9- 1·19	10- 3·00	9- 8·52	11·66	13·50	13·09	12·16	12·60
„ (2)	9-11·7	9- 1·12	10- 2·75	9- 9·21	11·44	13·00	13·19	11·81	12·36
„ (3)	10- 1·50	8-10·55	9- 9·92	9- 7·32	11·69	13·12	12·84	12·41	12·51
Medium	9-10·37	9- 1·70	9-11·50	9- 7·86	11·53	13·37	13·03	11·75	12·42
Coarse	9- 5·25	8-10·62	9- 4·62	9- 2·83	11·16	12·75	12·72	11·62	12·06
Very coarse	9- 0·37	8- 6·62	8-10·31	8- 9·77	10·25	12·47	11·97	11·12	11·45
Double banjhi only	9- 0·75	8- 7·40	8- 9·50	8- 9·88	10·28	12·03	12·19	10·69	11·30
Average	9- 8·14	8-11·15	9- 8·37	9- 5·22	11·20	12·97	12·80	11·71	12·17
Significant difference	0- 2·81p.	0- 2·70p.	0- 6·95p.	0- 2·59p.	0·39d.	0·56d.	0·39d.	0·67d.	0·25d.

Valuations on Souchongs.

Style of plucking.	India (annas and pies)				London (pence).				
	A	C	E	India Average.	H	J	K	L	London Average.
Superfine	8-7·25	8-5·00	8-10·62	8-7·62	10·63	13·34	12·91	11·84	1- 0·18
Fine (1)	8-5·25	8-4·56	8-10·50	8-6·77	10·47	13·72	12·59	11·56	1- 0·08
„ (2)	8-5·75	8-3·56	8-10·12	8-6·48	10·66	12·87	12·66	11·84	1- 0·01
„ (3)	8-6·25	8-3·12	8- 9·78	8-6·38	10·34	13·66	12·37	11·50	0-11·97
Medium	8-6·25	8 4·50	8- 9·50	8-6·75	10·53	13·06	12·50	11·34	0-11·86
Coarse	8-4·50	8-2·69	8- 6·50	8-4·56	9·94	12·72	12·25	11·28	0-11·55
Very coarse	8-3·12	8-0·50	8- 3·62	8-2·41	9·41	12·28	11·78	10·78	0-11·06
Banjhi	8-2·62	8-1·56	8- 2·50	8-9·23	9·28	12·09	11·72	10·62	0-10·93
Average	8-5·12	8-3·08	8- 7·91	8-5·37	10·20	12·97	12·35	11·35	0-11·72
Significant difference	1·62p.	1·65p.	2·43p.	2·63p.	0·53d.	0·42d	0·35d.	0·41d.	0·24d

All three tasters in India agree in making the teas made from the five styles of finer plucking significantly better than those made from the three coarser pluckings. They are also in agreement in preferring the teas made from fairly coarse plucking to those made from the "three leaves and bud" plucking and the "double *banjhi*" leaf.

Among the finer plucked samples, agreement between the three tasters is not so good. Taster A. puts the superfine pluck-

ing and the "not broken back" plucking significantly better than the other two styles of fairly fine plucking, and the medium plucking.

Taster C. significantly prefers the superfine plucking to the medium and "not broken back" styles, but not to the two other styles of finer plucking, *i.e.*, "broken back to *janam*" and "broken back to tipping level".

Taster E. valuing between wider limits than the others has a correspondingly large standard error and makes actually no significant difference between any of the five pluckings.

The average of the three results shows no significant difference between any of the three styles of fine plucking and the medium plucking. The superfine plucking is significantly preferred to the form of fine plucking in which long shoots were not broken back. The three coarser pluckings are significantly poorer than any of the stricter forms of plucking. Coarse plucking gives significantly better teas than "very coarse" plucking or "double *banjhi*".

The London tasters as a whole find no significant difference between the superfine plucking, the medium plucking or the fine plucking which was either heavily broken back, or not broken back at all. The fine plucking which was broken back to the *janam* is just significantly poorer than the superfine plucking. All forms of coarse plucking are significantly poorer than the finer forms of plucking. The teas made from very coarse plucking and *banjhi* leaf, are poorer than the teas made from coarse plucking.

In general, with the market showing comparatively little discrimination, the various forms of fine or medium plucking are not differentiated to any extent either in Calcutta or London; while, taking into account the increased crop from coarse plucking, this latter would have given a larger nett return than finer plucking, so small is the relative difference in valuation. The difference in price between "fine" and "coarse" plucking would have been counterbalanced by the increased cost of plucking alone. The 1934 market did not encourage better teas.

Analysis of Plucking Experiment Teas.

Analysis of Tannin, Caffeine, and total soluble solid matter, in 5-minute infusions of the eight sets of teas from different forms of plucking, were made.

The results are as follows :—

	Tannin %	Total Soluble solids %	Caffeine %
Superfine ...	7·21	26·3	2·02
Fine 1 ...	7·26	26·4	2·08
„ 2 ...	7·20	26·5	2·11
„ 3 ...	7·13	26·5	2·10
Medium ...	7·03	26·4	2·02
Coarse ...	6·43	25·5	2·03
Very coarse ...	5·77	25·4	1·88
Banjhi ...	5·77	25·2	1·85
Significant difference	0·21	...	...

There are no significant differences in caffeine or total solids, though there is a tendency for the finer plucked teas to be higher in both constituents.

In tannin content the fine and medium plucked teas are significantly higher in tannin content than the coarser plucked. The very coarse and *banjhi* teas have significantly lower tannin contents than the coarsely plucked tea.

E. INFLUENCE OF VARIETY ON THE QUALITY OF TEA.

Leaf was manufactured on six occasions weekly from the end of September to the beginning of November from plots containing the following varieties of tea.

Tingamira ... } Borbhetta.
Burma ... }
Indo-China ... }

Kharikatia ... } Tocklai.
Kalline ... }
China ... }

The following is a brief account of each variety and history of the treatment which each of the 6 plots has undergone since planting :—

I. *Tingamira.* This is a light leaf Assam variety, from an Upper Assam seed garden, originally planted with Betjan seed. The plots at Borbhetta were planted in 1921.

II. *Burma.* This is a small and dark leafed variety the seed of which was originally obtained from Croziers Agency, Silchar. The area was planted in 1920 and is close to the Tingamira block.

III. *Indo-China.* Seed was obtained from wild plants growing in the forests in French Indo-China. It is a little similar in appearance to China hybrid, but the leaf is bigger, thicker, and smoother; while the red colour in the young leaf, and axils of old leaves is very characteristic. The area at Borbhetta was planted in 1921, and is divided from the Tingamira block only by a narrow path.

The three from Tocklai are all in the same block and have always been treated identically.

IV. *Kharikatia.* This is a light leafed Assam variety being Singlo "once removed". It was put out at Tocklai in 1914.

V. *Kalline.* Seed obtained from the Kalline seed garden in North Cachar. The garden was planted with selected plants from Burma seed. Planting and treatment at Tocklai is identical with that of the Kharikatia area.

VI. *China.* Seed was obtained from bushes on abandoned teelas in Cachar. The parent plants of these bushes are reputed to have been brought direct from China. Treatment has been the same as that of the Kalline and Kharikatia jats.

The scheme of manufacture was as follows :—

Order of manufacture	Roller	Dates of manufacture					
		24-9	2-10	9-10	16-10	30-10	6-11
First	East	IC	T	KK	K	B	C
	West	K	C	T	B	KK	IC
Second	East	C	KK	IC	T	K	B
	West	KK	B	K	C	IC	T
Third	East	B	IC	C	KK	T	C
	West	T	I	B	IC	C	KK

T = Tingamira KK = Kharikatia K = Kalline
B = Burma C = China IC = Indo-China.

The teas were sent to five tasters in India and 4 in London. The valuations obtained are given below. One taster did not report on all batches of samples. His results therefore are not included in the report.

The combined results of the India tasters are as follows :—

Variety.	in annas and pies.					
	A	C	F	average	E	Average including Taster E.
Tingamira...	10-0·00	10- 0·83	9- 8·00	9-10·94	12- 4·00	10- 6·21
Kharikatia	9-6·83	9-11· 0	9- 2.83	9- 6·89	10-10· 5	9-10·79
Burma ...	9-4·00	9- 7·83	9- 2·17	9- 4·67	11- 7·67	9-11·42
Kalline ...	9-1·50	9- 7·67	9- 2·50	9- 3·89	10- 1·00	9- 6·17
Indo-China	8-7·50	9- 4·17	8-11·67	8-11·77	9- 1·33	9- 0·17
China ...	9-1·33	9- 4·83	9- 1·50	9- 2·56	9- 1·50	9- 2·29
Average	9-3·53	9- 8·05	9- 2·78	9- 4·79	10- 6·33	9- 8·17
Significant differences in pies.	3·56	4·20	2·38	2·22	11·40	4·05

Tasters A, C and F are in quite good agreement and the average of their valuations has a significant difference of only 2.22 pies. They place Tingamira significantly the best, Kharikatia significantly second. Burma is valued better than Kalline but the difference is not significant. China is valued lower than Burma and Kalline but not significantly. Indo-China is significantly poorer than any.

Taster E is valuing on a much wider basis than any of the others, but has a large standard error. He places Tingamira first, but not significantly better than Burma, which is preferred significantly to the other dark leaf jat Kalline, and to the two China varieties. These latter are placed significantly worse than the four other varieties.

The Kharikatia variety is placed lower than Tingamira and Burma, but the difference is not significant.

Results of Taster E should be regarded as a "minority" report, firstly because of his unique preference for Burma jat—an opinion shared by no other taster, secondly because he was valuing from the blenders' point of view, and thirdly because of his very wide range of valuations, which if combined with the other more conservative tasters, would unduly weight the average.

LONDON TASTERS.

Variety.	Valuation in pence				
	H	J	K	L	Average.
Tingamira ...	14·92	13·82	15·67	13·29	14·43
Kharikatia ...	14·08	13·21	12·92	12·37	13·15
Burma	13·25	12·79	12·92	12·21	12·79
Kalline	13·42	12·54	13·17	11·92	12·76
Indo-China ...	12·50	12·08	12·17	11·29	12·01
China	13·50	12·54	12·83	11·58	12·62
Average ...	13·61	12·83	13·28	12·11	12·96
Significant differences	0·62	0·49	0·87	0·50	0·41

The agreement between these four tasters is good enough to reduce the standard error of the average to a very small value. The Tingamira variety gives a tea which is very significantly the best and Kharikatia is significantly better than China or Indo-China. Burma and Kalline are not significantly better than China, but are significantly better than Indo-China. China is significantly better than Indo-China.

The opinions of the tasters both Calcutta and London, may be summarised briefly as follows :—

Tingamira and Kharikatia, light leaf jats, give strong coloury liquors with Assam character and bright infusions. The Tingamira is decidedly preferable in these respects, and in addition has much more tip in the dry tea. Both teas have a brownish colour when compared with dark leafed varieties. The Kharikatia variety gave more tippy teas than did the dark leaf or China varieties.

Burma and Kalline—strong coloury liquors, without stand-out quality. Infusions fairly bright but greenish and duller than the light leaf jats.

Burma is on the whole slightly preferred to Kalline, but except in the case of taster E, the difference is not significant. Both jats give very black teas, with a poor show of tip.

China. A thin liquoring tea with an undesirable character often referred to as "weedy" or "grassy". One or two of the later samples showed distinct Darjeeling flavour but not enough to off-set the thinness of the liquor. In tip and appearance the China tea is rather better than the dark leaf, but inferior to the light leafed jats.

Indo-China, gave a thin liquor with no quality. The samples of the last two manufactures had a touch of flavour, though this was referred to by two tasters as weedy or grassy. The dry tea had an almost blue-black appearance and was always entirely lacking in tip.

Analysis of the Jat Experiment teas.

Each of the six teas was analysed for tannin, caffeine and total solids, on each of the 6 occasions of manufacture. The analyses were made on 5-minute infusions which were made up in the manner described earlier in the report. The results are given in the following table :—

Variety.	Tannin %	Total solids. %	Caffeine. %
Tingamira	8·05	26·72	2·16
Kharikatia	7·75	26·75	2·09
Burma	6·89	25·05	1·97
Kalline	6·86	25·22	2·13
Indo-China	6·84	24·45	1·74
China	6·06	23·46	1·81
Average ...	7·08	25·28	1·98
Singnificant differences ...	0·48	1·24	0·33

The light leaf jats give infusions which are significantly highest in tannin and caffeine. Their caffeine contents, though significantly higher than either of the China jats are not significantly higher than the dark leaf jats in this respect. The China variety is lower in tannin and total solids than the dark leaf varieties and also, curiously enough, than the Indo-China variety. In caffeine there is no significant difference between Burma, Indo-China or China; Kalline is significantly higher in caffeine than Indo-China.

F. FIREPROOFING OF HESSIAN CLOTH FOR WITHERING CHUNGS.

Six experiments were carried out to see whether any deterioration of quality of tea resulted from treatment of the Hessian cloth on withering chungs, with a fireproofing solution.

The solution used was made up as follows :—

Ammonium sulphate	...	2½ oz.
Boric acid	...	¼ ,,
Water	...	25 ,,

The quantity of liquid required to soak 24 sq. yds. of hessian cloth was 1 gallon (containing 1 lb. of ammonium sulphate and 1¾ ozs. Boric acid). The cloth was dried thoroughly in the sun after soaking with the solution.

The strips of cloth, treated and untreated were stretched across wires on a wooden frame. Both treated and untreated cloth had 24 lbs. of leaf from the same plot, spread at the same time, and collected at the same time. The thickness of spread was the same for both, *i.e.*, 1 lb. per sq. yard.

During the six experiments the leaf from treated cloth was rolled three times in one roller and three times in the other; similarly with the leaf from the untreated cloth.

The withered leaf was weighed after collecting, on each occasion and the weights are recorded below :—

Weight of withered leaf from 24 lbs. fresh leaf, in lbs.

	Date of manufacture						average	100 lbs. leaf withered to.
	4/9	5/9	7/9	11/9	18/9	21/9		
treated ...	18·0	18·5	17·5	17·5	18·5	19·0	18·2	75·7
untreated ...	18·5	18·5	17·0	17·0	17·5	18·0	17·7	74·0

There is on the average a slightly higher degree of wither off the untreated cloth.

It was observed that the treated cloth, after the first manufacture was always slightly damp, even when it had not leaf spread on it for some days. The salts used in the treatment are obviously slightly hygroscopic, and absorb moisture from the damp atmosphere. The dampness of the cloth probably accounts for the lower degree of wither obtained in the case of leaf withered on the treated cloth.

The valuations of the teas made are given below :—

	Date of manufacture.						Average.
	4/9	5/9	7/9	11/9	18/9	21/9	
treated	9-10	9-6	9-0	9-2	9-2	8-9	9-2·83
untreated ...	10- 0	9-9	9-0	9-3	9-3	9-0	9-4·50

Significant difference is 1.22 pies and thus the treatment has resulted in a significant decrease in quality. The difference however is small and represents the opinion of only one taster.

It is considered unlikely that the small difference in wither between the two samples has caused the significant difference in quality as in the first manufacture the treated leaf had a higher wither than the untreated, but was still valued lower.

There is a possibility that the leaf becomes contaminated with very small quantity of salts used in treating the cloth, and fermentation may be affected thereby.

II. Soil Acidity.

Soil acidities were determined on about 1,500 samples of soil from various gardens and from plots under different treatments at Borbhetta and Tocklai.

Most of the soils sent from gardens were from areas of weakly tea and in many cases the soils were found to be too low in acidity to grow tea satisfactorily. These soils were put through a further test to determine the amount of sulphur necessary to bring the soil pH to 5.5 an acidity which is considered to be satisfactory for the majority of soils. There is much evidence however to show that, on certain soils, especially bheels and very stiff soils, tea yields better if the pH value is lower than pH 5.5.

Effect of Sulphur on Soil Acidity. The experiment to ascertain the effect of sulphur upon soil acidity has been continued but up to the present there are no significant differences

between the yields of the plots nor between the increase in crop over 1932 before treatment commenced.

Effect on soil acidity of various forms of nitrogenous manures. Cattle manure lowers the acidity of the soil as does also Calcium cyanamide to a greater extent. Horn meal, Oil-cake and Nitrate of soda have not significantly changed the soil acidity from the no treatment. Sulphate of ammonia has significantly increased the acidity. Blood meal has also increased the acidity to an extent that is just significant. Observations on the action of this manure during subsequent years will be of interest.

III. Effect of Green Crops on Nitrate Content of Soils.

Nitrate determinations were made weekly from March to October. The nitrates on all series of plots rose during the early part of April and reached a peak on the 23rd of the month for the series which had no green crop. On the plots which had Sulphate of ammonia, the nitrate content was just over 10 parts per million and remained well above the check plot for a period of five weeks. During this time the nitrates on the plots growing crops fell and remained very low in case of the Boga medeloa plots throughout the rainy season. On the plots on which the cowpeas were growing and which had been hoed in towards the end of May the jump in nitrates occurred after the crop had been hoed in but did not last more than a fortnight after which the nitrate content fell to the same level as in the other series. The nitrate figures render it not surprising that the yield of the green crop plots during this period compares unfavourable with that of the plots receiving the chemical manure. In the case of the cowpea plots the drop in yield consequent on the absence of the spring increase in nitrates was not made up by a rise in crop following the small increase of nitrates that occurred after the crop had been hoed in.

IV. Effect of Potash and Phosphoric Acid Manures on Growth and Nitrogen Content of Green Crops.

An experiment was carried out during April and May. The green crop used being cowpeas (*vigna cating*). Seed was sown

at the beginning of April and the crop harvested, weighed and sampled during the third week of May. Neither the potash nor phosphoric acid in any quantity alone has given a significant increase in crop. Potash and phosphoric acid in any combination have given a significant increase—the best being obtained from the maximum dose of both. The potash does not significantly affect the nitrogen content of the crop. The heaviest doses of phosphoric acid (160 lbs. per acre) without potash have increased the nitrogen content significantly.

As the main consideration in regard to the use of green crops is the amount of nitrogen they supply to the soil when hoed in, the total nitrogen which the crops from the various series would have supplied if hoed in are given in the last column of the table :—

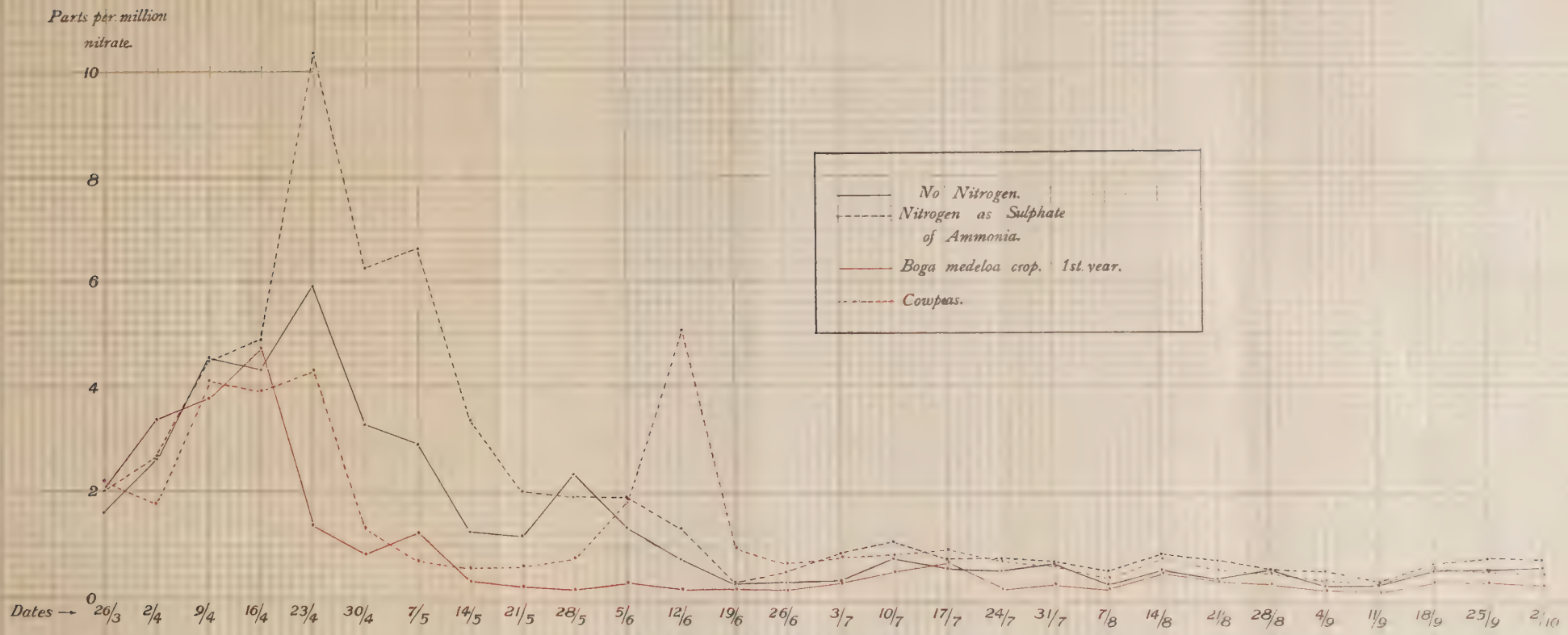
Series No.	Fertiliser lbs. per acre.		Percentage nitrogen on dry weight of leaf only.	Crop* in tons per acre	lbs. nitrogen per acre contained in the crop (leaf, stem and root).
	K.	P.			
1	0	0	3.74	1·42	13·7
2	40	0	3·85	1·72	16·0
3	80	0	3·84	1·75	15·7
4	160	0	3·91	1·69	15·4
5	0	40	3·94	2·26	24·9
6	40	40	3·92	3·48	36·3
7	80	40	3·75	4·36	38·9
8	160	40	3·81	3·78	34·5
9	0	80	3·84	2·33	26·1
10	40	80	3·84	4·32	43·6
11	80	80	3·97	5·30	52·2
12	160	80	3·91	5·07	43·8
13	0	160	4·18	1·69	18·3
14	40	160	3·94	4·46	45·2
15	80	160	3·57	5·34	50·7
16	160	160	4·05	6·55	55·7
Significant differences			0·37%	1·12 tons	11·1 lbs.

* These are weights of the actual crop as uprooted (not dry weight).

The crop curves do not indicate how much of the nitrogen has been taken from the air but rather suggest that in all probability it has been obtained from the soil in which case there has been no addition to the soil nitrogen.

GREEN CROP EXPERIMENT.

NITRATE CONTENT OF SOILS.



Manures applied 14. 3. 35. — *Cowpea hoed in 23. 5. 35.* — *Average crop 2. 63. tons per acre.*

Seed Sown 15. 3. 35. — *Boga medeloa lopped 23 .9. 35. loppings hoed in.*

ENTOMOLOGICAL.

This has remained on a maintenance basis and consequently no investigation work has been possible.

MYCOLOGICAL.

Specimens were received from all the tea districts of North East India. 1,252 specimens including 9 tea seed samples were reported on during the year.

Details of these specimens are given below.

Specimens of tea bushes affected by—

1.	*Auricularia Auricula judiae* (Jew's ear fungus)	2
2.	Bracket fungus	1
3.	*Cephaleuros spp.*, (Red rust)	3
4.	*Corticium invisum* (Black rot)	3
5.	Dead snag fungi	108
6.	*Fomes applanatus*	8
7.	*Fomes lamaoensis* (Brown root rot) ...	22
8.	*Fomes lucidus*	1
9.	*Glomerella cingulata* (Brown blight) ...	2
10.	*Glomerella major*	6
11.	*Helicobasidium compactum*	1
12.	*Hypoxylon sp.*	1
13.	*Kretzschmaria micropus*	5
14.	*Macrophoma theicola*	4
15.	*Marasmius pulcher* (Epiphytic Thread blight)	1
16.	*Nectria cinnabarina*	10
17.	*Nectria sp.*	6
18.	*Polyporus interruptus*	2
19.	*Poria hypolateritia* (Red root rot) ...	13
20.	*Rhizoctonia bataticola*	2
21.	*Rosellinia arcuata* (Black root rot) ...	3
22.	*Sphaerostilbe repens* (Violet root rot) ...	14
23.	Thread blight	5
24.	*Ustulina zonata* (Charcoal stump rot) ...	37

25. Various stem fungi such as *Glomerella major, Mycosphaerella sp., Cephaleuros spp., Pestalozzia theae, Diplodia* on moribund branches 3
26. Adverse soil conditions 35
27. Debility, etc. 22
28. Hail 1
29. Lightning 17
30. Mosquito blight 2
31. No disease 8
32. Red spider 4

Specimens of tea branches affected by—

1. Apple foliage blight 6
2. *Cephaleuros spp.*, (Red rust) 1
3. *Corticium invisum* (Black rot) 5
4. *Corticium Theae* (Black rot) 1
5. Dead snag fungi 2
6. *Glomerella cingulata* (Brown blight) ... 4
7. *Glomerella major* 7
8. Lichens 1
9. *Marasmius equicrinis* (Horse-hair blight) ... 4
10. *Nectria cinnabarina* 8
11. *Septobasidium bogoriense* (Velvet blight) ... 6
12. *Septobasidium tuberculatum* 1
13. Thread blight 3
14. Callus growth 3
15. Insects 8
16. Mosquito blight 2
17. No disease 7
18. Scale insects 1
19. Various fungi such as *Glomerella major, Mycosphaerella sp., Cephaleuros parasiticus, Pestalozzia theae, Diplodia* on morbund branches 3
20. Specimens of tea branches received from Tulsipara Big Manuring Plots, for leaf disease investigation 54

21. Specimens of tea branches obtained from Borbhetta Potash Phosphoric Acid Plots (Kharikatia and Tingamira) for leaf disease investigation 176

Specimens of tea leaves affected by—

1. *Cephaleuros mycoidea* (Epiphytic Red rust) ... 1
2. *Corticium invisum* (Black rot) 49
3. *Corticium Theae* (Black rot) 1
4. *Glomerella cingulata* (Brown blight) ... 13
5. *Laestadia Theae* (Copper blight) ... 2
6. *Limacinula Theae* (Sooty Mould) ... 1
7. *Phoma theicola* 1
8. Thread blight 3
9. Various leaf diseases such as *Glomerella cingulata, Pestalozzia Theae, Laestadia Theae, etc.* 5
10. Drought 1
11. No disease 2
12. Insects 2
13. Sun scorch 2

Specimens of tea seedlings and young tea plants affected by—

1. *Cephaleuros parasiticus* (Red rust) ... 4
2. *Diplodia* 1
3. Eelworms 53
4. *Fomes lamaoensis* (Brown root rot) ... 2
5. *Glomerella cingulata* (Brown blight) ... 46
6. *Glomerella major* 1
7. *Hendersonina sp.* 24
8. *Phoma theicola* 13
9. *Pythium sp.* 45
10. *Rhizoctonia sp.* 11
11. *Sphaerostilbe repens* (Violet root rot) ... 6
12. *Ustulina zonata* (Charcoal stump rot) ... 1
13. Debility 25

14.	Distorted roots	9
15.	Distorted roots and Eelworms	60
16.	Distorted stems	28
17.	Insects	1
18.	No disease	26
19.	Sun scorch	7
20.	Waterlogging	76
21.	Samples of tea seeds meant for export certification	5
22.	Samples of tea seeds not meant for export certification	4
23.	Specimen of a plucking basket affected by *Schizophyllum communis*	1
24.	Specimen of debris (deposited by flood round tea bushes) affected by Bracket fungus ...	1

Specimens of plants other than tea—

Name	Part affected	Disease	No. of specimens
Albizzia lebbek (White siris)	Branch ...	No disease	1
Albizzia stipulata (Sau) ...	Root ...	*Fomes applanatus* ...	1
Aleuritis Fordii (Tung) ...	Nil ...	No disease	1
Aleuritis Fordii (Tung) ...	Root ...	*Formes lamaoensis* (Brown root rot ...	1
Cinchona	Root and stem	*Fusarium sp.* ...	8
Cinchona	Root ... / Root and stem	Eelworm / Fusarium sp. ...	6
Dalbergia assamica (Bor medeloa)	Root ...	*Neocosmospora vasinfecta*	3
Derris robusta	Root ... / Stem ...	*Fusarium udum Nectria Bulbophylli* ...	3
Derris robusta	Branch ...	Bracket fungus ...	1
Plum	Stump ...	*Auricularia Auricula judiae* (Jew's ear fungus)	1
Shade tree	Root ...	*Ustulina zonata* (Charcoal stump rot) ...	1
Siris	Root ...	Lightning ...	1
Tephrosia candida (Boga medeloa)	Root ... / Stem ...	*Fusarium udum and Sphaerostilbe repens* (Violet root rot) ... / *Nectria sp.* ...	3
do	Root ...	*Fusarium udum and* Eelworms ...	3
do	Root ...	*Fusarium udum and* Eelworms ...	4
do	Stem ...	*Aschersonia sp.* ...	4

Miscellaneous—

1.	Botanical specimen for identification	...	1
2.	Specimen of "Alvesco spreader"	...	2
3.	Specimens of Burgundy mixture	...	2
4.	Specimens of freshly plucked tea shoots	...	4
5.	Specimen of Lethalata Wetting compound	...	1
6.	Specimen of Lysolid ...	...	1
7.	Specimen of "Malariol" ...	...	1
8.	Specimen of Rosin adhesive ...	...	1
9.	Specimens sent to Bacteriological Branch	...	2
10.	Specimen sent to Botanical Branch	...	1
11.	Specimens sent to Entomological Branch	...	6

Of the 1,252 specimens received and reported on in the course of the year the relatively large number of bushes and branches classed under dead snag fungi calls for comment. Every year large numbers of bushes become unproductive on account of the decay of their frames. Even on areas kept in first class order a bush here and there may be found with rotten branches. It may be said that with very few exceptions the bushes which die at Borbhetta do so on account of decay of the frame caused by infection of a pruning cut. Observation of decaying holes in tea bushes not suffering from debility suggests that a cut on which water does not accumulate usually heals without trouble but cuts, on which water accumulates during the rainy season are more liable to initiate decay. The waterproofing of such cuts by painting them with bitumen paint does much to prevent damage. Tar and other substances which have a tendency to crack are not so efficient as bitumen. The latter however requires renewal each year until healing is complete. It is particularly important to renew the paint on large flat cuts as the rim of callus forms a cup in which the water lies. The fungus concerned in the death of the tissues is almost invariably *Glomerella major*. As the fungus concerned is an exceedingly common one its eradication is out of the question. The *Glomorella* kills the tissues which are subsequently decayed by other organisms. It should be clearly understood that the foregoing

relates to bushes in normal vigour. Plants deficient in starch reserves tend to die back after severe pruning and no paint or other treatment will prevent the ultimate decay of branches which have died from lack of nourishment. Such branches must be cut out before the decay has time to invade the main frame.

Black rot continued to be prevalent in all tea districts. A number of gardens appear to have established control of this disease without undue expenditure by spraying infected bushes whenever they are found, throughout the season. There are, some areas, where conditions are particularly favourable to the blight, on which more comprehensive treatment appears to be necessary. A number of gardens in the Surma Valley were visited by the Mycologist in this connection.

Observations on susceptibility to Pests and Blights.

A long continued spell of wet weather in July and August, during which the soil moisture was above normal for most of the time, was associated with an outbreak of Brown blight (*Glomerella cingulata*) at Borbhetta, on the Kharikatia-potash-phosphoric acid plots to which an extra dose of 120 lbs. of nitrogen in the form of Sulphate of ammonia had been given in July. In the latter part of August one branch of the current year's growth was taken at random from every one of ten bushes selected at random from every one of the forty-eight plots.

About a month later there was a similar outbreak of Brown blight in the Tingamira 9-acre block at Borbhetta. In a similar manner one branch was taken from every one of ten bushes selected at random from every one of 128 plots.

From the 54 big manuring plots at Tulsipara at the end of the season 54 samples of pruned branches were collected at random within the plots. The leaves of these branches were examined for disease. Brown blight had not been sufficiently severe to call for any comment during the year but an examination of the leaves on the branches showed some disease to be present.

In all three areas observed the Brown blight attack bore no relationship to the manurial treatment of the plots.

Both the Kharikatia and Tulsipara bushes have been examined throughout the year for the amount of starch in the roots.

Samples of roots had been collected in the Kharikatia plot just before the severe attack of Brown blight. One root was taken from every one of 9 bushes selected at random in every one of the plots. The starch was estimated by the colourimetric iodine method. The yield was observed for two months prior to the attack of the disease. The data obtained yielded on examination the following partial correlations.

Starch and total leaves on current year's growth below the plucking level excluding yield ...	.626
Yield and total leaves on current year's growth below the plucking level excluding starch ...	.630
Percentage of old leaves blighted and starch excluding the total leaves on current year's growth below the plucking level ...	.386
Percentage of old leaves blighted and starch excluding yield	.472
Percentage of old leaves blighted and total leaves on current year's growth below the plucking level excluding yield	.071
Percentage of old leaves blighted and total leaves on current year's growth below the plucking level excluding starch	.010
Percentage of old leaves blighted and starch excluding yield and total leaves on current year's growth below the plucking level ...	.551
Significant correlation p=0.5 N=46 ...	.34

From these figures it is clear that the most important of the factors considered is the starch. The less the starch the greater is the percentage of old leaves attacked by the disease.

The results from the Tulsipara plots also show a similar correlation between the starch and the Brown blight.

The starch seems to have but little relationship to the amount of disease on the young leaves. It would seem that some other factor not so far considered is responsible for disease on young leaves. As in this particular case the difference between the columns and blocks of the experiment arranged as a latin square were insignificant it would seem that the particular factor has been operating equally over the whole area.

The Tulsipara experiments show that a negative correlation exists between the amount of starch during the early part of the season (16 weeks) and the Helopeltis attack at the latter part of the season, that is to say, the greater the amount of starch in the earlier part of the season the less is the Helopeltis attack in the latter part of the season.

Starch in the roots of Tea Bushes. The observations on the Kharikatia plots at Borbhetta had indicated no definite relationship between the manurial treatment varying in respect of potash and phosphate with a constant amount of nitrogen (120 lbs. per acre). The Tulsipara experiments show that with an increased nitrogen application the starch in the roots tends to be less and this is so after allowance is made for the increased crops produced by the larger doses of nitrogen.

Manure.			Starch expressed as percentage of general mean.	Starch expressed as percentage of general mean adjusted to equal yield.
N.	P.	K.		
0	0	0	103·8	103·9
40	0	0	101·8	101·7
40	40	0	101·4	101·2
40	0	40	102·5	102·5
40	40	40	101·3	101·4
40	0	80	100·6	100·7
80	0	0	96·4	96·3
80	0	80	97·2	96·9
80	0	160	95·0	95·4
Significant difference ...			4·4	.....

The observations both at Tulsipara and on the Kharikatia plots at Borbhetta show a correlation between the starch and the yield.

Borbhetta starch and yield	...	.568
Tulsipara starch and yield	...	.902

In last year's report it was pointed out that the starch content was less on bushes collar-pruned compared with those that have been medium pruned on the same date (1928). A further examination of the bushes this year shows that while there is still a considerable difference in crop of 1.4 mds. per acre the difference in starch is small when allowance is made for differences in the yield.

Treatment of pruning cuts. The bushes pruned and the pruning cuts treated with bitumen mixture, sodium silicate and lime sulphur in the year 1932 were used for observing the effect of the different treatments after two years.

The results obtained suggest that the effect of the bitumen mixture, although very satisfactory during the first year, had disappeared after two years. This emphasizes the results obtained by examining the bushes concerned microscopically at the end of the second year.

Observations on Seedling Diseases.

Specimens of seedings and young plants were received in considerable numbers. The exceptionally wet conditions in some districts caused many young seedlings to rot at the collar. In some cases the plants seemed to have died as a direct result of water-logging. In other cases seedlings grown on soil taken from bad patches in nurseries both in the Dooars and Upper Assam had a fungus growing with very delicate filaments which was damaging the plant tissues just above the soil level. The fungus was identified as *Hendersonina sp.* probably *Hendersonina Sacchari* which occasionally causes collar rot on young sugar-cane plants in North East India. It should be possible to control this disease without difficulty in nurseries by fungicidal applications.

Observations on Eelworms in Tea Seedlings. An experiment was started to determine the effect of various soil disinfectants on seedling disease caused by Eelworms. Two separate areas were marked out in squares 2 ft. × 2 ft. separated from each other by 1 ft. It was considered whether a distance of 1 ft. was sufficient to separate the various squares. Mr. Buckley, the Helminthologist of the London School of Tropical Medicine was asked his opinion when he visited Tocklai. He considered that since the larvae of the worms tend to move upward rather than sideways infection from one plot to another was more likely to take place by mechanical means such as by coolies' feet, hands and cultivation instruments than by the larvae passing of their own accord sideways from one plot to the next.

There were 32 squares in each area arranged in four lines of eight each. The soil in every square was removed to a depth of 6 inches and placed in one heap. A water suspension of Eelworms (from ten seeds) propagated in the laboratory, was mixed with the heap. The soil was then replaced in the holes. One area was shaded with a thatched roof while the other was covered with thatch laid on the squares after planting. Germinated seeds were planted two inches deep, two inches apart, in lines of two inches apart, each square containing 100 seeds. Each area contained two latin squares of 4 plots × 4 plots. The three treatments and a check were repeated four times in each square. The sequence of the rows was randomised.

Eight squares in the shaded area were watered with 1/8th gallon of 1% formalin and another eight squares were watered with 1/8th gallon of 1% solution of a proprietory disinfectant. The top soil (about two inches) of each of another eight squares was mixed with 1 oz. of powdered napthaline. The remaining eight plots were left untreated.

The squares in the unshaded plot were planted in the same way as above but they were treated differently. In eight squares, each of the germinated seeds was planted with 2 grains of powdered naphthaline. The other squares were planted without any special

treatment. They were covered with chopped straw a few days after planting. Eight of them were subsequently watered with 1/8th gallon of 0.5% formalin solution and eight were watered with 1/8th gallon of 0.5% solution of the proprietory soil disinfectant. The remaining eight were kept as a check.

When the seedlings reached a height of about two inches (*i.e.*, after two months from the date of sowing) the plots which received half strength solutions at the time of sowing were treated a second time with solutions of the same strength.

After about four months from the date of sowing the seedlings were dug out and the intensity of the Eelworm attack was recorded.

The following table gives the results obtained :—

A Formalin.
B Proprietory disinfectant.
C Naphthaline.

Treatment.	Eelworms.				% of plants with distorted roots.		% of plants with distorted shoots.	
	% of plants infected.		% degree of infection.					
	Shaded.	Unshaded.	Shaded.	Unshaded.	Shaded.	Unshaded.	Shaded.	Unshaded.
None	21·5	100	8·54	92·08	82·75	85·37	51·87	57·37
A.	15·5	100	6·08	88·70	85·12	86·12	51·87	61·62
B.	12·25	100	4·58	82·54	78·5	84·25	41·12	56·12
C.	15·75	100	6·87	86·37	88·12	88·12	67·75	68·75
Mean	16·25	100	6·52	87·47	83·62	85·97	53·15	60·97

The average infection of the eight untreated plots of the shaded area can be compared with the average of the eight untreated plots on the unshaded area.

On the unshaded area every plant was infected with Eelworm whereas on the shaded area only 21.5% were infected. This difference is so big that although these results cannot be expressed as having a statistical probability yet I think they can be regarded as significant.

On the shaded area the 1% Proprietory disinfectant gave a significantly improved result.

Although the shading showed greater freedom from Eelworm attack yet there is no significant difference between the shaded and unshaded areas in respect of distorted roots and shoots thus indicating that neither Eelworm nor shade can be regarded as factors affecting these results.

Many of the roots in the plots receiving the Naphthaline had a bitten off appearance caused by the death of the growing tips.

The Eelworm principally concerned has been identified by Dr. M. J. Triffitt of the Institute of Agricultural Parasitology, England, as Heterodera marioni (Cornu 1879) Goodey 1932. This was later confirmed by Mr. Buckley, Helminthologist of the London School of Tropical Medicine, during a visit to Tocklai. This Eelworm can only reproduce itself in living roots. As it attacks many other plants commonly present on tea soils it has no difficulty in carrying on in the absence of tea seedlings. Mr. Buckely expressed the opinion that it would be necessary to bare fallow soil for at least a year before the larvae of the Eelworms died of starvation. The use of crops to attract the larvae was also discussed. He pointed out that it would be necessary to remove all the roots of the trap plants from the soil before the females produced eggs. This would be a matter of some difficulty.

Mr. Buckley seemed to think that treatment of the soil with boiling water was a possible method of controlling this Eelworm in nursery beds.

Possible reasons for the heavy infection of old cultivated land on gardens where uncultivated land was comparatively uninfected were also discussed.

So far most of the plants found growing on cultivated land round Tocklai have been found to be badly infected by the same Eelworm while plants of the same species growing on uncultivated land only a few feet away have been found free from infection.

Eelworm on Cowpea. The Cowpea plots at Tocklai were badly attacked by Eelworms. The roots from each plot were grouped according to the intensity of the attack. They were marked as follows—3, very bad; 2, medium; 1, slight; 0, unattacked.

The results of this estimation are given below—

Series No.	Manure lbs. per acre.		Eelworm series totals.							
	P.	K.	P=0	P=40	P=80	P=120	K=0	K=40	K=80	K=120
1	0	0	18	...	..	...	18	...	...	...
2	0	40	15	...	...	...	...	15	..	...
3	0	80	12	...	...	...	..	...	12	...
4	0	120	15	...	...	...	...	...	..	15
5	40	0	...	18	...	...	18	..	...	...
6	40	40	...	18	...	...	..	18	...	...
7	40	80	...	17	...	...	...	...	17	...
8	40	120	...	20	...	...	...	...	...	20
9	80	0	...	...	17	...	17	...	...	...
10	80	40	...	...	18	...	...	18	...	...
11	80	80	...	...	16	...	...	...	16	...
12	80	120	...	...	18	...	...	...	...	18
13	120	0	...	...	...	14	14	...	...	...
14	120	40	...	...	...	20	...	20	...	...
15	120	80	...	...	...	18	...	...	18	...
16	120	120	...	...	...	19	...	...	...	19
Manure	group	totals	60	73	69	71	67	71	63	72

Significant difference (p = .05) between individual series totals = 5.6.

Significant difference between manure group totals = 11.3.

It will be seen from the above that the manures applied had very little effect on the Eelworm infection.

Specimens of cowpea roots from Borbhetta plots which were sown a little earlier but with the same seed showed no signs of Eelworm infection.

The following table is obtained by taking the average yield of similarly infected plots in each group and expressing them as a percentage of the mean yield of all the plots.

Manure.	Degree of Eelworm infection.	
	Slight & Medium.	Bad.
Phosphate	Yield.	
0	49	32
40	102	95
80	134	108
120	142	115
Potash.		
0	55	45
40	101	100
80	124	112
120	139	119

From the above figures it would appear that the badly infected plots yielded less than similarly manured plots with less infection.

Taking all the observations into consideration it appears that the manures had little effect on the Eelworm infection but had some influence on the amount of crop produced.

As only 3 plots out of 128 were uninfected it is impossible to estimate the actual loss in crop associated with the Eelworms.

Observations on young plants with a view to making a selection in the Nursery. In the course of the investigation of the Eelworm infection four unshaded and four shaded plots were dug up each week the first being taken sixteen weeks from sowing. One half of the unshaded plots were sown a week later than the others. The number of unserrated leaves below the serrated ones, the number of serrated leaves below the *banjhi* bud and the number of serrated leaves above

the *banjhi* leaf were recorded on all plants in suitable condition for such a record.

The following figures show that the number of unserrated leaves on the unshaded plants was higher than that on the shaded ones. This was true also of the serrated leaves.

Age from sowing in weeks.	Shaded.					Unshaded.				
	16 & 17	18 & 19	20 & 21	22 & 23	Total	16 & 17	18 & 19	19 & 20	20 & 21	Total
Total plants	510	565	587	566	2228	312	284	226	191	1013
Average number of unserrated leaves	4·71	4·69	4·65	4·74	4·70	5·12	5·31	4·99	5·26	5·17
Average number of serrated leaves	4·68	5·42	5·77	6·37		6·41	6·80	7·91	8·32	
Sum of average unserrated and serrated leaves	9·39	10·11	10·42	11·11		11·52	12·11	12·90	13·58	

It was noticed that many of the shaded plants went *banjhi* after producing the first cycle of serrated leaves, the unshaded ones however showed a greater tendency to continue growth without this *banjhi* period.

It is obvious that the shaded and unshaded parts of a nursery must be considered separately in regard to any method of selection based on counting the number of leaves produced in a given period.

All the serrated leaves of sufficient size were measured on seedlings selected in the first two collections from both shaded and unshaded plots of the Eelworm experiment. Tables were prepared for 1st, 2nd, 3rd, 4th and 5th serrated leaf, counting from below. In the tables the length divided by the breadth of the leaf is plotted against the number of unserrated leaves or leaf scars below the serrated ones.

In the case of the shaded plots all the measured leaves were taken into consideration as there were too few plants with complete series of five leaves. In the case of the unshaded plots only those plants which had a complete series of five leaves were

included in the tables. Thus in the latter series the respective serrated leaves were all produced on the same plants.

The following tables show the averages of length divided by breadth.

Number of unserrated leaves.	Serrated leaves.					
	1st.	2nd.	3rd.	4th.	5th.	Average
			Shaded plots.			
4	1·66	1·70	1·81	1·99	2·12	1·86
5	1·78	1·74	1·82	1·93	2·15	1·88
6	1·76	1·77	1·83	2·13	2·40	1·98
Average	1·73	1·73	1·82	2·02	2·22	1·90
			Unshaded plots. (All series from the same plants).			
4	1·88	1·86	1·97	2·06	2·17	1·95
5	1·90	1·98	1·97	2·09	2·25	2·04
6	1·89	1·99	1·98	2·09	2·16	2·02
Average	1·89	1·94	1·98	2·08	2·19	2·01

A high ratio of length over breadth indicates a narrow leaf, whereas a small ratio indicates a broad leaf.

The above figures show that there is a tendency for plants grown in the shade to produce broader leaves than the unshaded ones.

The above tables also suggest that each successive leaf in the first cycle of serrated leaves is narrower than its predecessor. There is also an indication that the greater the number of unserrated leaves the narrower are the leaves in the succeeding cycle of serrated leaves. In other words there is a tendency for the serrated leaves to become narrower the higher their position on the plant.

In order to make comparisons between seedlings in regard to the broadness of their leaves it is therefore necessary to take into consideration the position of the leaves as well as the conditions under which they have been grown.

BACTERIOLOGICAL BRANCH.

In the absence of the Bacteriologist on 7 months home-leave, the work of the Branch during the past year has largely been confined to the accumulation of routine data.

Some of the data has shown :—

(*i*). Valuable direct information :—The result of analyses of rolled leaf throughout the year demonstrate the possibility of manufacturing throughout the season with a low bacterial count in the leaf.

(*ii*). The necessity for improved technique :—Direct counts of bacteria of green leaf indicate the difficulty of accurately differentiating between tea and foreign bacteria on the shoot by the method at present employed.

No such difficulty is experienced in counting foreign bacteria on rolled leaf.

BACTERIAL NUMBERS.

Bacterial counts on green leaf.—Counts, as far as possible, were made weekly on leaf from the Kalline plot at Tocklai. It was intended that these counts should be differential, tea and foreign bacteria being recorded separately. In practice it was found that the relative growth of tea bacteria was frequently so rapid that foreign bacteria could not be identified with any certainty. It has, however, been established that the numbers of foreign bacteria occurring on the green shoot are much higher than the numbers found in clean rolled leaf from the Tocklai factory. It is difficult to explain this with the present state of our knowledge but the possibility must be considered that some of these bacteria may be suppressed during manufacture in a similar manner to the tea bacteria and may therefore be of no importance during manufacture. This subject requires further study with an improved technique.

The total numbers of bacteria on green leaf fluctuated throughout the year. There is some indication that the fluctuations correspond with the growth curve of the bush but the correlation is not at present definite.

A consideration of the data so far obtained indicates :—

(1) high bacterial numbers during April,

(2) from mid-May to mid-July a tendency to low numbers,

(3) during late July and August an increase in the numbers,

(4) during September and early October lower figures,

(5) during October and November again increased numbers.

The total bacterial count was not seriously influenced by the leaf being wet. Where counts of foreign bacteria have been obtained, fluctuations rather similar to those of last year are shown although the peaks in the curve do not necessarily occur on the same data. There is one noticeable difference in the later half of April, when the foreign bacterial count was high in 1934, this being the reverse of what was found in 1933. The difference may be in part attributable to the wet conditions during April, 1934.

Foreign bacteria in rolled leaf at Tocklai. No difficulty was experienced in counting the colonies in this case since the tea bacteria rarely appeared.

An interesting problem is thus provided, *i.e.*, why tea bacteria will develop in large numbers in green leaf whilst in fermenting leaf they either do not appear or appear only after long incubation. It would seem that the juice expressed in rolling has a paralysing effect on the tea bacteria rendering them incapable of growth if not actually destroying them. This effect has repeatedly been noticed in the past.

When not obviously influenced by external factors bacterial counts made on fermenting leaf from individual rolls have shown

a close agreement and indicate that when working under clean conditions the infection in fermenting leaf may be lower than was previously considered normal. The following are the figures obtained from Tocklai factory :—

Date of Manufacture.	*Bacteria per gram of fermenting leaf.*
12th June, 1934	... 1,480
24th July, 1934	... 2,080
15th September, 1934	... 10,800
26th October, 1934	... 510

An examination of a considerable number of samples has given an indication of roller infection, insufficient in degree to affect the fermenting leaf but suggesting the extent of infection which might occur in factories where bacterial control methods are not in force. In some instances the infection has been confined to the earlier rolls of the day presumably due to the presence of decaying leaf particles which had been left from previous manufacture. These were removed in the earlier rolls, the infection falling in subsequent rolls.

20-7-34.		22-9-34.		16-11-34.	
Roll No.	Bacteria.	Roll No.	Bacteria.	Roll No.	Bacteria.
1	6,000	5	14,200	1	2,600
2	5,600	6	12,000	2	2,400
3	600	7	4,400	3	600
4	700	8	6,000	4	140
5	500			5	200
6	520			6	240
7	600				
8	300				

It is more common, however, to find a greater infection in one roller than in the other persisting throughout manufacture

suggesting the origin in some defect in the roller, as for instance deposits of juice in crevices of the roller cap.

The figures fluctuated widely but even the highest represent a low figure for bacterial infection. The counts show that with the intense cleaning methods such as are employed at Tocklai combined with careful handling of leaf during manufacture, bacterial infection can be kept at a negligible quantity. Out of a total of 177 rolls only 2 had counts of more than 1,000,000 bacteria per gram, whilst only 29 showed infection greater than 10,000 bacteria per gram, of which 24 were below 50,000 per gram.

Bacterial analyses were made at frequent intervals on leaf from a local factory. The object of this series of analyses was to determine what degree of infection was likely to be present in leaf throughout the year at the start of manufacture thus providing a criterion of cleanliness to which samples might be referred.

This series of experiments was also used to ascertain the degree of accuracy which may be expected from single plate counts. When plating material where the approximate number of bacteria is known, as in soil counts, it is customary to prepare 5-10 plates of a single dilution so that the average may be obtained with a relatively high degree of statistical accuracy. In determining the bacterial counts of leaf an estimate of the count can seldom be made, since infections may vary between a few hundreds and several millions. This requires the use of a range of dilutions from 1/100 to 1/1,000,000. If 5 dilutions and 5 plates of each dilutions are employed, one series of analyses will require 25 plates for each sample analysed, a number beyond the capacity of the Bacteriological Branch, both in apparatus and space.

A typical series of counts is given below, showing the mean of 5 plates and the highest percentage divergence from the mean of any one series.

Date.	Mean count.	Standard error.	Highest divergence from mean.
21-8-34 ...	17440	604	11·22%
28-8-34 ...	11280	555	11·86%
5-9-34 ...	16680	450	7·93%
13-9-34 ...	7880	97	3·56%
21-9-34 ...	58200	1748	7·22%

It may therefore be accepted that the single plate method gives sufficient accuracy for general factory analyses, since the plate counted can be checked by reference to the plates on either side with dilutions higher and lower. For critical work the multiple plate method may be necessary.

The figures taken throughout this year suggest that the initial count after the first roll is more dependent on a slight infection in the roller than on natural factors since the variation in bacterial numbers cannot be correlated with a natural condition. The average infection after the first roll is approximately 10,000 bacteria per gram of which a certain number were originally present on the leaf. A similar infection may be anticipated during successive rolls if the rollers are equally clean, giving a total for 3 rolls of approximately 30,000 bacteria per gram. The normal increase in bacteria during 3 hours after the first roll is in the region of 36%. A clean working factory under Assam conditions should thus produce fermenting leaf with an average infection not greater than 50,000 bacteria per gram. Anything in excess of this probably may be regarded as preventable infection.

QUALITY OF TEA.

Precipitation of tannin by acid. In 1933 it was shown that the development of bacteria in fermenting leaf was accompanied by an increase in the percentage of tannin that can be precipitated by 2% of hydrochloric acid, and that when a tea was stewed during firing, producing dull infused leaf and soft

liquors, the percentage of tannin precipitated by acid was reduced. This work indicated a possible method of differentiating between a bacterial infection during manufacture and bad firing as a source of dull infused leaf and soft liquors Out of a total of 47 samples of tea manufactured at Tocklai 38 shewed figures lower than 12% for the tannin precipitated by acid, the average being 6.66. The remaining 9 samples average 14.2 and the highest figure obtained was 16.2 per cent of tannin precipitated by acid. These results tend to conform with those obtained in previous years. The results do not yet allow of definite conclusions being drawn.

The continuation of the stewing experiment commenced in 1933 has given results similar to those obtained before—stewing appears to convert a portion of the tannin into a form not extracted in a 5-minute infusion, or into a form not precipitated by acid. In either case, in the liquor, the percentage of tannin precipitated by acid becomes less.

	Moist tea unheated.	Heated in open tin.	Heated in closed tin.
Total tannin % ...	8·96	7·86	8·41
After acid pptn. ...	7·05	6·78	7·40
% tannin pptn. ...	21·3%	13·85%	12·0%
Total tannin % ...	8·16	7·42	6·98
After acid pptn. ...	5·84	6·07	5·56
% tannin pptn. ...	28·4%	18·2%	20·3%

Inoculation experiments. Several experiments were conducted with bacteria introduced into leaf rolled in the Tocklai factory with the object of studying the effect of bacteria on tannin, more particularly on that fraction precipitated by 2% hydrochloric acid.

Suspensions of bacteria were introduced into leaf which had been rolled for 1 hour, and thoroughly distributed by hand. 3¼

to 4½ hours fermentation was allowed, bacterial counts being taken at the end of fermentation.

The results of this series of experiments confirm the observations made in 1933, that bacterial infection may lead to an increase in the percentage of tannin precipitated by 2% hydrochloric acid. The results suggest that the species of bacterium concerned is of major importance in determining the results of the infection. A systematic study of infecting bacteria is therefore necessary.

Bacterial metabolism. One of the obstacles which has arisen during the investigation of the effects of bacteria on tea constituents has been the difficulty in producing bacteria in pure culture with the same activity that they possess when growing on fermenting leaf. It has been shown (Annual Report 1932) that when bacteria develop on fermenting leaf they possess high catalase activity. These bacteria grown in pure culture show a barely recognisable catalase activity. Many species of bacteria growing on fermenting leaf produce a neutral or alkaline reaction. The same bacteria in pure culture produce an acid reaction. It seems probable that the effect of bacteria in producing dull infused leaf and soft liquor is largely due to the development of a neutral or alkaline reaction. It is evident therefore that factory conditions cannot be accurately reproduced in pure culture experiments unless the metabollic processes of the bacteria are approximately the same in both cases.

Attempts to obtain an alkaline reaction by growing bacteria on an extract of green leaf have failed. It was considered that the controlling factor in determining the final reaction might be certain conditions of growth since in leaf extracted or in culture fluids a relatively small surface is exposed to the air while in fermenting leaf the bacteria are distributed in a thin film of juice over the surface of the leaf. To reproduce this effect experiments were made in which the culture fluid, either artificial or leaf extract, was distributed over sand. A moisture content of 60% or less of the saturation point was found satisfactory. A culture of bacteria from a Sylhet factory in both liquid

and sand cultures developed an acid reaction in a peptone and glucose culture medium. When peptone alone was employed, an alkaline reaction developed rapidly in the sand culture whilst little change occurred in the inoculated liquid. With an extract of green leaf a similar effect was observed but the rate of change was less. This method may prove of value in inoculation experiment. An interesting point is that the sand culture showed a definite catalase activity which was absent from the liquid cultures. The method will, however, require further investigation since analyses showed that some 30% of the tannin could not be removed from the sand by washing.

Mould in Tea. Further investigations on the destruction of heat by moulds in finished tea have been made. In the 1933 Annual Report it was suggested that the proportion of the moulds present on the tea leaf were in a form resistant to heat and that destruction at a temperature used in firing machines could not be effected until the moulds had taken on a less resistant form, *e.g.*, by germination or incipient germination of the spores. It was shown that at the end of the manufacturing season under conditions of low vapour tension, this change did not take place readily and that the moulds remained in a heat resistant form for a considerable period. It was suggested that this effect would not be found during conditions of high humidity, and the results of the past year substantially confirm this view. The method employed was to obtain a sample of finished tea fresh from the dryer, this being placed in a receptacle where it was protected from external infection whilst being allowed free contact with the atmosphere. Samples were removed at intervals and heated for 20 mins. at 80°C. (176°F). After heating, 40 leaf fragments were embedded in lentil agar and incubated for several days. They were then examined for mould growth. The degree of infection was expressed as the percentage of leaf particles showing a mould infection, one particle out of 40 infected representing 2.5%.

In interpreting the figures given below it must be borne in mind that separate samples were withdrawn from the bulk for

each heating and since there was a slight variation among the samples, the percentage of particles carrying moulds after heating may vary. It is also possible that the moulds on leaf particles lying within the bulk may behave differently to those on leaf particles on the outside. This also would introduce a variation.

Percentage of particles of tea infected with moulds.

	29th May	12th June.	29th June
Initial Infection	97·5	65·0	62·5
Heated after—			
1 day storage...	20	...	10
2 days ,, ...	2·5	...	...
3 ,, ,, ...	sterile	7·5	sterile
4 ,, ,, ...		sterile	

In sample taken during May and June the moulds are found to lose their resistance to heat fairly rapidly, sterilisation by heat being effective in three to six days. During July the following figures were obtained :—

Percentage of particles of tea infected with moulds.

	Date of Manufacture.			
	10th July	13th July	17th July	20th July
Initial Infection	87·5	92·0	50·0	70
Heated after—				
1 day storage	70	25	25	7·5
2 days ,,	...	...	22·5	...
3 ,, ,,	22·4	17·5	25	...
4 ,, ,,	7·5	5	...	12·5
5 ,, ,,	...	...	...	5
6 ,, ,,	...	7·5	...	sterile
7 ,, ,,	10	...	15	...
8 ,, ,,	...	32·5	sterile	...
9 ,, ,,	2·5	...	...	...
10 ,, ,,	sterile	17·5	...	...

Although almost complete sterilisation is obtained in a few days, in two instances a residual infection remained. The rise in the sample of 13th July suggests external infection after sterilisation.

A very different state of affairs was found in samples obtained towards the end of the season, in which sterilisation could not be effected even when one sample was kept for 15 days.

Percentage of particles of tea infected with moulds.

	Date of Manufacture.		
	18-9-34	30-10-34	16-11-34
Initial Infection	92·5	37·5	37·5
Heated after			
1 day storage	36·1	30	25
2 days ,,	...	45	...
3 ,, ,,	70	25	...
4 ,, ,,	65	45	15
5 ,, ,,	...	...	22·5
6 ,, ,,	45	17·5	10
7 ,, ,,	35	22·5	12·5
8 ,, ,,	50	...	...
9 ,, ,,	47·5	30	...
	25 after 15 days.	...	...

The chief difference between these figures and those obtained earlier in the year lies in the fact that although the above series shows no ordered variation, the earlier figures show on the whole an increasing susceptibility to heat as time progresses. These observations are too scattered to allow of definite conclusions being drawn but they provide support for the theory put forward last year.

Experiments to determine the effect of moulds on the keeping power of teas were continued. As in the previous year samples of tea infected with moulds and samples of the same teas

which had been sterilised by heat, were kept in a damp atmosphere for at least a month so that a high moisture was acquired.

The results of this season's tests show that sterilised teas keep better than infected teas when a high moisture content (up to 12%) is present in both. Even the sterile teas lose character under these conditions, but their features are maintained better than is the case when moulds are present. Finally the infected teas become visibly mouldy, hyphae appear on the surface of the leaf—and the teas become unsaleable, a condition which does not arise in the sterilised teas.

Since a full range of figures has not been obtained, it is not proposed to deal with the subject further in this report, but the investigations will be continued.

BOTANICAL

The investigations are incomplete which deals with the flush periods of the bush and the effects of plucking on plucked and unplucked shoots on the same bush; the effect of pruning and plucking on the formation, rate of growth and maintenance of plucking surface; and the investigation of periodic growth and *banjhiness*. It would be inadvisable to discuss this season's experiments until the results have been analysed in greater detail than has been possible up to present.

In 1934 two definite routine schemes of research have been initiated—

(1) the isolation and definition of varieties of tea,

(2) the definition of varietal and seasonal variations in the hairiness of the tea leaf and relationship of the seasonal variation to the physiology of the tea bush.

Before giving the results of this year's work it is, I think, advisable to indicate what may be expected from the first of these investigations.

THE ISOLATION AND DEFINITION OF VARIETIES OF TEA.

1. *Varieties of the tea plant.* The need for the study of jats is, not, perhaps, generally realised by the average manager who, moreover, is usually in the position of having to make the best of the tea which he finds on the garden. On the other hand it is becoming evident that some of the problems of tea manufacture, such as the production of "quality" teas, might be solved, at least in part, before the factory door is reached, or even before applying manure: I refer to the importance of studying the characteristics of different varieties of tea and also to the fact that the tea bush continues for many years. From a purely business point of view the tea bush represents a large amount of invested capital and it is therefore just as well to invest this capital wisely and with fore-thought. The planting of five or six different *jats* on one garden cannot be regarded as a wise investment as such a procedure will help each of the jats to nullify, during manufacture, any particular characteristics of the other jats. Also, in spite of the recognised necessity of examining tea seed for freedom of infection from unwanted fungi, insects pests, etc.; the need of examining for freedom of infection by unwanted and undesirable varieties is by no means so generally realised. Until comparatively recently no means of identifying jats had been devised—and indeed the work is still only in its infancy. The Botanical Branch is devoting a considerable amount of time to this work, which, it may be mentioned, is of extreme difficulty. The report upon tea varieties jats has been divided into two sections, in the first giving instances of the need for an accurate system of jat identification, and consequently what may be expected to result from this investigation, and in the second giving a brief summary of the results already achieved.

Practical Examples of the need for Varietal Identification.

In the scientific investigation of flavour and quality. High elevation teas have long been noted for flavour and/or quality, and one of the fundamental points in any investigation of the factors causing flavour and quality, must be to compare and con-

trast the growth and chemical constitution of bushes at high and low elevations. But before it can be determined what factor accounts for the superiority of the tea in one place as compared with another, it must be quite certain the variety of tea is the same in both cases; or, if the variety is different, in what respects it is different. The planter has not the means of making the necessary determination and the mere assertain that the bushes in two places are the same jats proves nothing, but frequently adds to the existing confusion. This statement particularly applies to the type "China", "China hybrid", or "Hybrid", which are names covering all possible mixtures of innumerable varieties of tea. Unfortunately, when dealing with high elevation teas, these are the types which have to be made the basis for scientific observations and some further differentiation and definition is urgently required. It cannot be too strongly maintained that, because two lots of tea bushes are said to belong to the same jat, they are not necessarily identical either in type of green leaf or in the quality of the tea manufactured therefrom.

In determining a suitable variety for planting out a particular area. Take as an example a certain garden which wishes to replant, and of the varieties of tea with which we are familiar at Tocklai, it is known that, taking into consideration the locality and soil of the garden, only three jats are suitable. But seed of these jats is expensive and the manager finds that he can procure seed from other sources which is said to be the same, and is apparently identical with, one of the desired jats how can the manager be certain that this is so—the interests at stake are too great to take any risks, yet there is the possibility of a considerable saving in capital outlay. Up to the present we have been able to give no answer to such a problem, but a continuance of the present investigations should enable one to be given whenever necessary.

In examination of seedling plants in the nursery for purity of "jat". Another important application would be the examination of seedling plants in the nursery for purity of jat.

What little advice Tocklai has been able to give in the past has always referred to plants in a fairly advanced stage of growth, when it has been impossible to remedy the presence of unwanted types of tea. A continuance of the present lines of research so as to include seedling plants would, in all probability, enable identification to be made of a variety of tea in its first year of growth from seed.

In type of leaf in relation to quality of manufactural tea. It has already been pointed out that one character of the leaf, *i.e.*, hairness, is associated with desirable qualities in the manufactured tea, and it is thus possiblle, by examining the hairiness of the leaves of different jats, to estimate their potentialities as "tip" producers. There seems to be no reason why continued investigation of the characters associated with different jats should not disclose other characters of the leaf associated with other desirable qualities in the finished tea.

In selection and improvement of existing varieties. All the foregoing points refer to the identification of *jats*, but there is a second issue to the work, *i.e.*, that of further selection and improvement, but this perhaps, is not at the moment of immediate commercial importance; at the same time, the possibilities of further selection are by no means to be overlooked—they will eventually be required and should therefore be put in hand at once, as successful selection of a plant like tea is a process taking a considerable number of years. Selection of tea on the scientific principles of genetics has not yet been practised in the tea industry and given a sufficient lapse of time would doubtless effect great changes. The fact that a given bush, owing to its genetic constitution, may or may not produce seedlings like itself seems to have been entirely overlooked in the selection of existing seedbaris: a batch of seedlings of different years but all from one bush may be alike, but need not be the same as the mother bush; thus "seed" may be very constant, but different from the bushes in the seed-garden. It is therefore evident that any selection which is practised on the seed garden ought not to be practised on the characters of the seed bush but on the characters of the

seedlings derived from that bush. A further extension of this principle is that a bari may be composed of bushes which are, as tea bushes, perfectly homogeneous; yet these same bushes which, as producers of leaf, are all exactly alike, may differ in their genetic constitution so that, as producers of *seed,* they are not exactly alike, and the progeny of one bush may differ markedly from the progeny of another bush : thus, any amount of selection of the bushes of the seed-garden alone is not bound to result in satisfied customers.

As it is a perennial crop, all tea in cultivation may be regarded as the first generation of a progeny from particular seed trees. Hence the question of breeding true to type is not of immediate importance to the tea industry. What to the practical man is of first importance is a seed garden which will give a satisfactory and sufficiently homogeneous population in the first generation from seed. For this it seems of more or less fundamental importance that a seed garden should be established by vegetative propagation.

Results of the 1934 investigation.

(1) Of the tea which is grown at Tocklai four distinct types of wild tea may be recognised; and possibly, and not with such certainty, a fifth wild type may be recognised. The initial recognition of these types is fundamental and is the basis of the investigation.

The general characters of these five types (varieties) are given below :—

Variety I. (Usually referred to as "Burma"). Leaf generally small, but may, on cultivated bushes under shade, become noticeably large. Leaf generally carried erect, and only rarely, and in the case of unusually large leaves, is it drooping. Lamina not characteristically bullate. Lateral veins indistinct and immersed in the tissue of the lamina so that a prominent superficial veination on the undersurface of the leaf is almost absent. The characteristic small, erect, leaf is invariably folded upwards along the length of the mid vein : this character tends to vanish with large leaves. The whole of the

periphery of the leaf is serrated. A dark leaf type : this character is best judged from the undersurface of the leaf. The tip of the leaf is distinctly caudate and in large leaves is twisted. The junction of the lamina with the petiole is characteristically acuminate.

Bushes growing under natural conditions are highly branched and very floriferous.

Variety II. (conveniently designated as "Manipuri"). This is the least well marked of the types grown at Tocklai and exhibits the greatest variation between bushes. The type is similar to "Burma" (variety I), but differs in having typically, broader and rounder leaves, slightly bullate, less erect (but, nevertheless, not drooping) and rarely folded along the mid vein. The leaf is equally as dark as that of "Burma". The junction of the lamina with the petiole is marked by a distinct "shoulder" which in extreme cases becomes slightly auriculate.

Bushes growing under natural conditions are less branched and less floriferous than those of "Burma".

Variety III. (Commonly known as Lushai). Typically a large leaf jat, the smallest leaves of which are usually above the average leaf size of "Burma". Leaves invariably drooping, with the point of the leaf directed downwards. Leaves prominently bullate and light in colour. The tip of the leaf is well-marked, caudate and typically twisted laterally. The laterals and many of the subsidiary veins stand out from the lower surface of the leaf as a prominent reticulation. The junction of the lamina with the petiole is gradually acuminate.

Bushes growing under natural conditions are very sparsely branched and in the early stages of growth consist mainly of unbranched leading shoots. Less floriferous than Burma.

Variety IV. ("Naga"). Leaf noticeably long and narrow; very gradually acuminate to the caudate tip which is not twisted. Leaf hardly bullate, erect at the base, tending to droop slightly towards the tip : the tip is distinctly gouge like, *i.e.*, folded up along the length of the mid vein, while the lamina of the leaf is

not generally so folded. Leaf moderately light dull green, but not so light as Lushai. Laterals and subsidiary veins on the lower surface of the leaf prominent : lateral veins very numerous and at a rather acute angle with the mid vein. Junction of the lamina with the petiole very gradually acuminate.

Bushes growing under natural conditions are highly branched and very sparsely floriferous.

Variety V. ("High Elevation Burma"). A very distinct type with medium sized leaves characterised by their extremely dark colour and very glossy upper surface. The leaf is not in the least bullate and there is an almost complete absence of prominent veins on the lower surface of the leaf. Serrations indistinct and confined to the distal part of the leaf which terminates in a long and distinctly twisted point. The junction of the lamina and petiole is very gradually acuminate. Leaves are carried erect on the stem and tend to fold upwards along the length of the mid vein. The extreme margins of the leaf tend to roll under towards the lower surface. Bud scales are distinctly tinged with red (as also the base of the petiole) and fringed with long hairs. The bush retains a leader very late in life and has the habit of a small tree. Flowers and fruits unusually large.

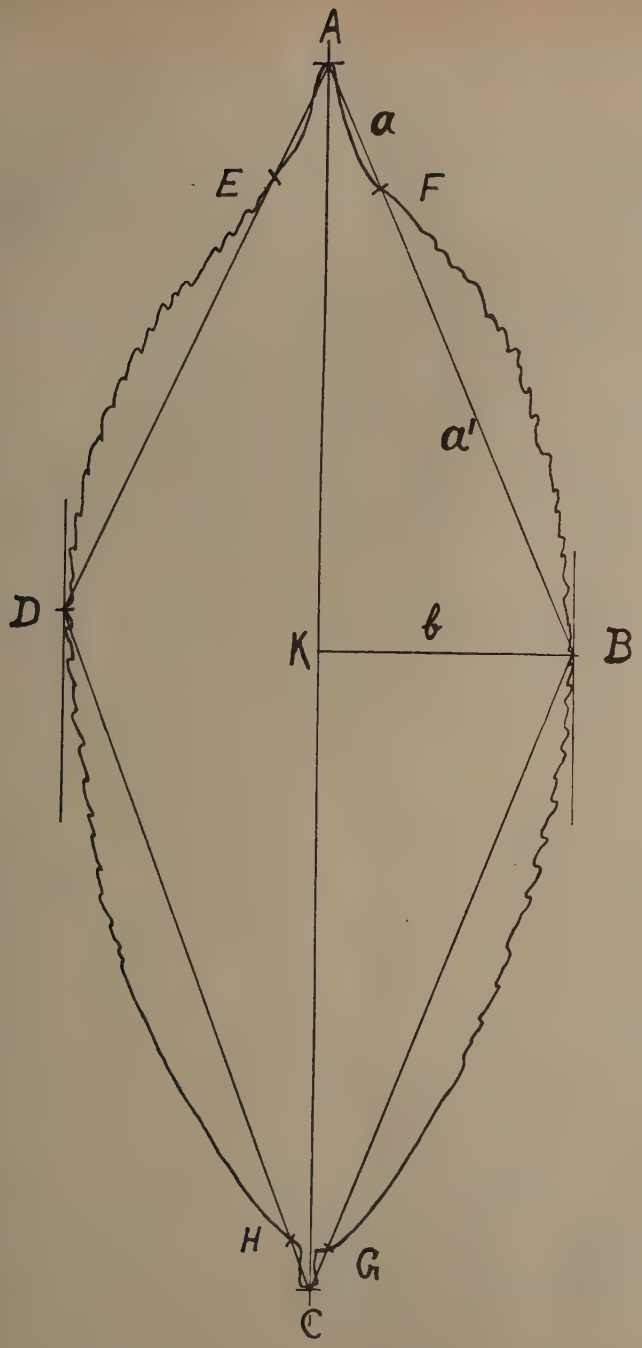
It will be desirable, but by no means absolutely necessary, to express the differences between these (and other) types on a numerical basis.

With this end in view mathematical indices of leaf shape, and the mean number of stamens per flower, have been examined statistically in the case of the five types mentioned above.

Measurement of leaf shape for the calculation of representative mathematical indices is carried out as follows. The system depends upon the fixing of four cardinal points upon the leaf. The leaf is laid upon a transparent, glass topped, table, and illuminated from below by a powerful light. A second sheet of glass is laid over the leaf, and a sheet of semi-opaque paper is placed over this second sheet of glass. A shadow of the leaf is cast upon

the paper, which shadow, with a powerful and even source of light below the table and with sufficiently thin glass above the leaf, gives an accurate and sharply defined outline of the leaf. This shadow outline is the basis of the subsequent construction, for which a parallel (rolling) ruler and an ordinary lead pencil are the only apparatus required. The following constructions are made. Points indicating the extreme tip of the leaf and the base of the petiole are marked on the paper and a line is drawn so as to join these two points. This line is regarded as the centre of the leaf, whether the line coincides with the central vein of the leaf or not. The ruler is now drawn to one side until the edge of the ruler is seen to form a tangent with the periphery of the leaf : the point of tangent is marked and this indicates the widest part of the leaf on one side of the previously drawn central line : the ruler is now moved across the leaf in the opposite direction and the widest part of the leaf on the other side of the central line is marked. In all, four points have now been marked (A, B, C and D below), and these four points are joined so as to form a trapezium. At this stage the outline of the leaf and the superimposed geometrical construction appears facing this page.

It will be seen that the various parts of the figure may be expressed as innumerable ratios, some of which, in addition to the ratio BF/BK, seem likely to be of diagnostic value. For the purposes of the investigation, each measurement of length, angle, radius of curvature, number of serrations, etc., based upon the construction as given above, is regarded as a unit leaf character. These in themselves, vary with the size of the leaf, but the ratio of one such character to another may or may not vary with leaf size and may or may not be indicative of varietal differences. The question of variation with leaf size is important and for the present only those characters (simple ratios of unit characters) which can be proved to be independent of leaf size (expressed as length of leaf) are being investigated. It does not, however, follow because some character varies with leaf size, that that character is useless for diagnostic purposes, as the difference between two supposed varieties may lie in a difference in the



$$K'_2 = \frac{a_1}{b} = \frac{BF}{BK}$$

It will be seen that the outline of the leaf makes contact with the sides of trapezium at four points other than those already marked. The position of these points of contact (E. F. G. H.) are characteristic of a particular variety of tea, and may be expressed as various mathematical ratios, *e.g.*, BF/BK.

nature of the variation. It is nevertheless, better to concentrate first on those characters which are easily expressed as forms independent of leaf size and leave the more abstruse cases (which are decidedly in the majority) for subsequent examination.

An examination of the foliar character K2 for the Jaipur seed trees has shown a mean value of 0.45 and the biggest variation from this figure for any progeny that has so far been examined at Tocklai has shown a mean value of 0.43 with a standard error of the difference equal to $\pm$ 0.007. In view of these figures it has been decided to accept a minimum difference of four times the standard error to establish a significant difference.

An examination of leaves of variety 2 of the wild types recognised at Tocklai has shown a mean value for K2 equal to 0.42. Variety 4 shows a mean value of 0.36. The standard error of the difference is $\pm$ 0.014. The difference is greater than four times the standard error and is accepted as indicating a true difference between these varieties.

The investigations have so far shown that floral characteristics, *e.g.*, the number of stamen of a flower is likely to form a reliable diagnostic characteristic although the possibility of a variation in stamen number with different flushes of flowers requires investigation. The production of flower on the tea bush, in the first place, is governed by the periodic flushing of the shoots. When flower buds open different generations of flowers can be observed as succeeding each other and these different generations of flowers are found to correspond with preceding periods of flush of the shoot. It is thought that the different generations or flushes of flowers differ from each other in the mean number of stamens. It is probable that a significant average difference in the stamen number indicates an irreversible difference that is to say a difference that is irreversible in one generation from the parent.

An examination of the Jaipur seed trees have shown the mean number of stamens per flower to be 155.9 with a standard error = 3.12. Of the progeny from Jaipur seed trees which shows

the greatest variation of those examined the mean number of stamens per flower is 164.5 standard error = 3.27.

The mean number of stamens per flower has been determined for the five distinct types of wild tea already referred to above with the following results :—

		Mean Stamen number.	*Standard error.*
Variety	I ...	145.95	4.46
,,	II ...	144.77	3.84
,,	III ...	145.38	2.73
,,	IV ...	144.93	2.22
,,	V ...	219.15	3.78

As a difference of three times its standard error is required in order to establish a significant difference, Varieties I, II, III and IV must be regarded as identical whilst variety V is significantly different. The observations for variety V are based upon that of a single bush. An application of these methods to commercial varieties which look superficially alike has shown a differentiation based on the stamen number, for instance—

	Standard error.
Variety Betjan growing at Tocklai mean number of stamens per flower	155.74 1.87
Variety Tingamira growing at Tocklai mean number of stamens per flower	180.56 2.33

Variety Betjan falls into the same class as the four wild type varieties I, II, III and IV whereas variety Tingamira is significantly different.

Hairiness of the tea leaf. It is well-known that the production of "tip" is dependent upon the presence of hairs on the leaf prior to manufacture. It has also been recorded that different varieties of tea show marked differences in the amount of hair

which is to be found on the lower surface of the leaf. In view of these facts the Botanist has been engaged in determining the relative degrees of hairiness of different varieties of tea; and as it is known that the amount of hair on the leaves of a particular bush, or variety, is subject to fluctuations from time to time, without, however, there being any knowledge as to whether these fluctuations were contemporaneous on all varieties, it has been necessary to make continuous records of the degree of hairiness, extending over a whole season, for all the varieties which it was desired to examine. Six "jats" were selected for examination, it being considered that these would give figures applicable to the majority of the tea in cultivation in North East India. The commercial designation of the "jats" are as follows :—

(1). Tingamira.
(2). Betjan.
(3). China.
(4). Kalline.
(5). Burma.
(6). Panighat.

Leaves for examination consisted of samples of 50 leaves each, taken at random from all the shoots plucked on a particular day : only those shoots were taken which had just, on the day of plucking, unfolded two serrated leaves above the plucking surface : from each shoot, taken at random from the crop plucked, the lowermost leaf was taken for examination. The results are thus sufficiently independent of any system of plucking, as they refer only to a particular stage of development of the shoots in relation to the plucking level and on that shoot only to a particular leaf the mean age of which is known (10 days expanded from the bud and approximately 40 days old dated from its formation as an initial by the growing point).

The leaves are preserved in 30% alcohol with an admixture of 15% pure glycerine and are examined by reflected light, using a blue light filter to compensate the reddish colour of the preserved leaves; as the hairs are colourless, this method increases the contrast between the hair and the leaf. Camera lucida draw-

ings are made of the hairs on the unit areas of the leaf. Subsequent to making the drawings, the numbers of hairs on the unit areas are counted and the sum for the areas is indicative of the "degree of hairiness" of the leaf : the average value of 50 such determinations gives the mean degree of hairiness of one sample. One sample was taken from each of the above six jats at every other plucking round during 1933 and the material so collected will be completely analysed. The unit area selected for examination is one of approximately 5 sq. mm. : this is an arbitrary area, taken as a matter of practical convenience and is a compromise between variation in the size of the leaf examined, magnification necessary to ensure accuracy, possible magnification of the apparatus, depth of focus of the objective necessary to avoid continual refocussing and the ruling on the sectional paper used for recording the results.

It has been noted that after the second flush of the year the crop plucked shows no marked separation into periods of flush, the production of leaf then remaining at a more or less constant level : but in spite of this, the degree of hairiness of the leaf subsequent to the second flush shows a distinct fluctuation in periods corresponding with the periods of growth of unplucked shoots. Figures obtained for "Betjan" distinctly show that the fluctuations in the hairiness of the plucked leaf are associated with the periods of growth and banjiness—*i.e.*, the flush periods —of the tea bush. Other figures for "Kalline" show that in this "jat" the periods of hairiness occur at times different from those of "Betjan" : this difference may be due either to some differences in the times at which the "Kalline" bushes pass into the periodically recurring *banjhi* phase, or may be due to the response to plucking differing between "Kalline" and "Betjan".

AGRICULTURAL

Under the Restriction Act no new planting could be done. The nett area, excluding area occupied by drains, paths, and roads, therefore remains at

58.6 acres at Borbhetta.
4.4 ,, at Tocklai.

Permission has been received for further planting of 16 acres of tea. Such an area does not provide for many new experiments, but even so small an area is very valuable. 10 acres of land for this planting have been cleared and levelled, and nurseries have been prepared for planting in 1935/36.

The 5¼ acres of youngest tea were not plucked in 1934. It has been completely infilled, and was shaded by hedges of boga medeloa in alternate lines; very weak plants receiving also an artificial dressing. This area is still uneven, but has greatly improved.

The 9¾ acres planted 1928/29 yielded 31,276 lbs. green leaf, equivalent to 88 mds. tea against 61 mds. in 1933. 3½ acres of it had become even enough to be used for experiments on plucking and another 1¼ acres for experiments on green crops, in 1934.

The experiments made on the 3.2 acres of Lushai tea, and 3.6 acres Burma tea were completed at the end of 1933, and it is now intended to get these two areas even again for future experiments.

Both areas had been under manuring experiments such that, in 1933, the best plots were giving over 20 mds. tea per acre and the worst were down to 6 mds. The worse the yield in 1933, the more manure was given in 1934, while the best plots were left unmanured. In addition, the worst plots were left unplucked for the whole of the season; and others, not so bad, for part of the season. All these made wonderful growth. The whole area was cut back to 18″ in October-November 1934—partly because bushes must not be too high when experiment recommences, and partly because the heavy cutting is expected to have a great effect

in reducing the best bushes towards the level of the worst. This area gave 71.3 mds. tea in 1934 against 89.1 in 1933.

The plots previously most heavily manured, (120 lbs. nitrogen per acre annually) but completely unmanured in 1934, gave to the end of October

1933 ... 19.18 mds. tea per acre.
1934 ... 18.44 ,, ,, ,, ,,

The drop is very small in spite of the cessation of the manuring, which was always with soluble artificials. This very heavy manuring had never given an effect proportional to its quantity, and presumably a lot had remained unused.

The 2½ acres Betjan tea cut back to 22" in November 1931 gave leaf equivalent to 39 mds. tea against 33 last year, and may now be considered back to full yield.

The 2½ acres of Bazaloni tea similarly cut a year later gave 28 mds. tea against 12 mds. in 1933, and 33 mds. in 1932 before cutting; and is now almost back to full yield, having been assisted by a manure mixture supplying 80 lbs. nitrogen in 1934.

Of the remaining area, parts are still gaining under steady manuring, but about 21 acres are considered now to be varying in crop only under seasonal influence. This area yielded 67,680 lbs. leaf against 66,000 in 1933, so that the seasonal increase is estimated at about 3%. High-lying, well-drained areas yielded better in 1934 than in 1933, but a low-lying area showed a serious drop in crop. The increase was all made in the early months, late crops being considerably below those of 1933. This year's increase at Borbhetta is ascribed to the very unusual complete absence of the "green-fly stunt". Early quality was much worse than in any previous year, and was as bad from unmanured as from any manured plots. There was a drought in March which was beneficial rather than otherwise, when followed by good rain; but from about mid-April onwards the soil was continuously sodden and the atmosphere too nearly saturated. It is considered that quality tea cannot be produced under such conditions.

The late teas were better than usual, showing autumnal character although no marked flavour, and were well valued, considering the market.

The total yield from Borbhetta in 1934 was 2,673 mds. green leaf equivalent to about 601 mds. pucca tea. 2,400 mds. green leaf were sold at Rs. 2/4/- per maund.

Export rights were sold at annas -/4/9 and manufacturing rights at annas -/1/6. The total receipts of Rs. 23,014/5/6 exceed the expenditure on Borbhetta by Rs. 652/6/-.

Except for the relatively small fraction used for manufacturing experiments, the leaf from Borbhetta is not manufactured. Strictly, yields should be expressed in lbs. green leaf; but this method of expression would render results less easily appreciated. Yields therefore are recorded in the following pages in mds. tea per acre, assuming that 100 lbs. green leaf would make 22½ lbs. made tea.

The statistical methods used were explained last year (Annual Report for 1933, pp. 183-186). There was no change in 1934 and the explanation need not be made again, except to repeat that the errors to which results reported are liable are indicated by the "significant difference" also reported.

"Significant difference" is

"standard error" $\times \sqrt{2} \times t$ for $P = .05$ (Fisher).

The odds then, are 20 to 1 on any difference between treatment averages exceeding the "significant difference" being due to treatment, and not to chance error.

TRIALS OF DIFFERENT VARIETIES.

Yields from the Tocklai Clearance were in mds. tea per acre :—

Light leaf indigenous		Dark leaf indigenous		China
Kharikatia ...	14·94	Kallino	14·74	11·06
Singlo ...	14·90	Panighat	13·73	...
Betjan ...	13·61	...	...	...

Half of each plot was unpruned in 1934, and the unpruned tea did very badly.

Leaf from the Kharikatia, Kalline, China plots was manufactured on 6 occasions separately, and at the same time light-leaf Tingamira—a light leaved Assam, Burma and Indo-China leaf from Borbhetta.

The Tingamira was picked out by all tasters on practically every occasion, as having the best quality and true Assam character. Kharikatia was similar but was considered to give rather thinner liquors. The two dark leaf varieties were less highly valued, the Burma from Borbhetta being slightly preferred to the Kalline from Tocklai. The China had a sort of flavour which was considered undesirable except in the autumn when it was liked by most tasters but not by all. On the whole it gave relatively poor teas. The Indo-China was considered rather similar to the China, but on the whole even less valuable.

A full account of these experiments is given in the Report of the Chemical Branch.

PRUNING.

Trials of Unpruned Tea.

(1). *The Tocklai Clearance.*

Each of the plots of the six different varieties is divided into two equal sub-plots, one of which is pruned annually in December, while the other is pruned in alternate years only in December.

Only in the first two years of the experiment, when the tea was young (planted 1914) and being plucked over long growth, was there any real gain from leaving unpruned; crops in mds. tea per acre, being :—

1920	pruned to 14″ plucked at 27″	4·69	plucked unpruned		11·62
1921	pruned at 16″ plucked at 27″	8·89	pruned at 14″ plucked at 27″		8·20
	Total	13·67			19·82

Since then, the tea, when left unpruned, occasionally gave more than the annually pruned tea, when the season was favourable to unpruned tea, but the total crops 1922 to 1933 (12 years) have been :—

Annually pruned	...	159.1 mds.
Pruned in alternate years	...	148.5 ,,

There can be little doubt, that quality also has suffered from leaving unpruned.

These later average losses from the use of unpruned tea are ascribed mainly to increasing damage to frames from wood-rotting fungi attacking at large snags of dead wood left on the bush for two years. With annual pruning only small snags are left and these are removed at the end of each year before much harm can be done.

Yields over the last 6 years have been :—

	mds. tea per acre		
	annual pruning	alternate year pruning	
1929 ...	15·52	15·45	
1930 ...	15·54	13·95	(unpruned)
1931 ...	14·82	15·61	
1932 ...	15·36	13·73	(unpruned)
1933 ...	14·40	14·25	
1934 ...	14·95	12·85	(unpruned)
total	90·19	85·84	

It will be observed that during these years, the tea pruned in alternate years yields, when unpruned, distinctly less than the annually pruned tea ; and about the same as annually pruned tea in the years when both sets are pruned.

The fact that we get less crop when the tea is unpruned than when it is pruned is directly contrary to what is observed on most gardens, and indicates some radical difference in conditions,

which is difficult to guess at. Perhaps this tea which has not been cut back since 1916 now needs the stimulus of pruning. The plucking at Tocklai may perhaps be too close, after pruning, to get good crops when unpruned.

(2). *The Introduction of an Unpruned Year during the Building Up of a Young Bush.*

Although it is well to avoid cutting on thick wood near the base of a bush (all the tea left unpruned after collar-pruning at Borbhetta and Tocklai still shows large numbers of unhealed wounds, where cut on two-year-old wood at 6″ or 8″ from the collar up to 18 years ago) it is possible to obtain the benefit of increased growth from leaving young tea unpruned only once, or perhaps twice. The following experiment exemplifies this. The block of Rajghur tea at Borbhetta was planted with one-year-old plants in November, 1924, low centred a year later, and plucked at 30″ in 1926. On part of the clearance alternate lines were left unpruned in 1927, while the intermediate lines were pruned between 12″ and 15″. Since then pruning has been the same for both, to 18″ before the 1928 season, 20″ for 1929, 22″ for 1930, 23″ for 1931, 24″ for 1932, 24½″ for 1933, and 25″ for 1934.

Yields in mds. tea per acre have been :—

	Annually pruned.	Unpruned in 1927 only then annually pruned.
1927 ...	3·84	7·60
1928 ...	5·45	5·87
1929 ...	8·51	9·56
1930 ...	9·52	10·62
1931 ...	12·66	13·64
1932 ...	11·75	12·09
1933 ...	13·34	13·97
1934 ...	14·22	14·78
Total ...	79·29	88·13

Not only was a big gain made in the unpruned year, but the unnecessary removal of leaf and stem from the already small bushes in 1927 had a bad effect for several years. Callus formation over some of the larger wounds made on 2-year-old wood is not even yet complete; but in this case these wounds are high enough in the bush to enable removal if damage occurs, certainly at a loss less than the gain already made.

Although very small, the difference, even in 1933, was still significant (the trials are fifteen times repeated).

The difference in 1934 is not quite significant.

(3). *The three-acre Tingamira Block at Borbhetta.*

This is used for trials of the effect of (*a*) date of pruning; (*b*) interval between prunings, and (*c*) cleaning out.

Each treatment is 7 times repeated in 7 blocks of 10 plots each.

Results in 1934 were :—

Plot-set.	Interval between pruning.	Cleaned out.	Date of pruning.	Mds. tea per acre.
1	1 year	yes	December 1st 1933	12·38
2	,,	no	,, ,, ,, ...	10·24
3	,,	yes	January 10th 1934	11·91
4	,,	yes	February 19th 1934 ...	9·72
5	1½ years	yes	May 10th 1933	14·32
6	,,	yes	July 10th 1933	15·57
7	2 years	yes	April 7th 1932 and 1934 ...	8·24
8	,,	no	,, ,, ,, ,, ,, ...	7·78
9	,,	yes	June 19th/32 and June 10th/34 ...	7·12
10	,,	yes	Sept. 9th/32 and Oct. 30th/34 ...	12·62
			Significant difference ...	1·25

(*a*) *Effect of date of pruning.*

Annual pruning in cold weather.

This comparison now extends over 5 years, during which results have been, in mds. tea per acre :—

	Pruning dates.		
	December 1st.	January 9th.	February 19th.
1930...	10·19	8·87	7·62
1931...	13·27	12·16	9·62
1932...	13·11	12·04	10·54
1933...	12·42	12·06	9·26
1934...	12·35	11·91	9·72
Total ...	61·34	57·04	46·76

The later pruned tea comes into bearing later (compare monthly crops from plot-sets 1, 3 and 4 in the table on p. 88). For the first three years there was no gain at the end of the season to counterbalance this loss. In 1933 and 1934 January-pruned tea does gain a little on the December-pruned from September onwards; while the February-pruned tea gains both on the December-pruned and on the January-pruned tea, during November in 1934, though not in 1933.

The losses from pruning in January compared to December are not statistically significant either in 1933 or in 1934; but the losses over the first three years were highly significant. The loss from pruning in February is significant even in 1934. Manuring experiments show that, except where water-supply or disease is a limiting factor, the main factor influencing crop is nitrogen supply. Late pruning, by using a shorter portion of the growing season, produces a smaller crop; but, in consequence, less of the nitrogen available is used, and the unused balance must come into action at some future date, unless the treatment producing the smaller crop reduces the efficiency of the bush as a nitrogen-using leaf producer, as late pruning does not.

It will be observed from the table (p. 88) that practically all the loss from late pruning falls on the second-flush tea, and it is for this reason in particular that early pruning is advised.

Pruning in the growing season.

Pruning in April, May, June, July and September also is tried. The effect is similar to that of pruning in February but losses are greater since the time lost covers more heavily flushing periods of the year. It is clear therefore that it is perfectly hopeless to expect anything but heavy loss from annual pruning at such dates.

The pruning in April, June and September has therefore been performed at intervals of two years; while the pruning in May and July has been at roughly 1½ years interval, the intermediate pruning being on December 1st.

Whenever tea is pruned there is a loss in crop, firstly while it is growing up to the measure decided upon for plucking, and secondly while the bushes are filling up after the first tipping. This filling-up process takes a considerable time during which later pruned bushes are behind earlier pruned bushes. All are at their best about a year after their last pruning after which time the later pruned bushes begin to show the effect of the stimulus of more recent pruning by yielding better than earlier pruned bushes.

This may be observed in the crops plucked monthly over the last two years.

1933 mds. tea per acre.

plot-set.	date of pruning.	to end March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
6	Dec. 1st. 1931	0·98	0·96	0·76	1·58	pruned.				.....
7	Apr. 7th. 1932	0·95	1·28	1·17	2·17	1·86	2·27	1·85	2·24	0·95
9	June 10th. ,, ...	0·93	1·03	1·20	2·38	1·87	2·24	1·84	2·05	0·91
10	Sept. 9th. ,, ...	0·60	0·61	0·86	2·49	2·42	2·72	2·28	2·53	1·20
1	Dec. 1st. ,, ...	0·01	0·08	0·36	1·54	1·90	2·45	2·21	2·58	1·27
3	Jan. 19th. 1933	nil	nil	0·20	1·51	1·75	2·49	2·24	2·50	1·29
4	Feb. 19th. ,, ...	nil	nil	0·02	0·66	0·96	1·93	1·99	2·35	1·35
5	May 10th. ,, ...	.....	.....	nil	nil	0·20	1·82	1·29	1·80	1·09
6	July 10th ,, ...	.....	.....	.....	.....	.....	nil	0·04	0·49	0·57

1934 mds. tea per acre.

plot-set.	date of pruning.	to end March	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.
7	Apr. 7th, 1932	0·91	pru	ned	.....	.....	.....	.....	.....	.....
9	June 10th. ,, ...	0·83	0·94	1·07	pr	uned.	.....	.....	.....	.....
10	Sept. 9th ,, ...	0·98	0·83	1·08	1·44	2·00	1·01	2·15	2·53	pruned
5	May 10th, 1933	0·90	1·32	1·24	1·58	2·16	1·67	2·10	2·52	0·83
6	July 10th. ,, ...	0·72	1·09	1·39	2·02	2·56	1·93	2·36	2·65	0·88
1	Dec. 1st. ,, ...	.....	0·11	0·31	1·68	2·13	2·08	2·41	2·65	0·98
3	Jan. 9th. 1934	.....	0·05	0·12	1·46	1·83	1·91	2·57	2·93	1·04
4	Febr. 19th. ,, ...	.....	.....	0·05	0·65	1·16	1·54	2·34	2·87	1·11
7	Apr. 7th. ,, ...	.....	.....	.....	0·01	0·45	1·05	1·81	2·53	0·97
9	June 10th. ,, ...	.....	.....	.....	.....	.....	0·14	0·76	1·64	0·77

(*b*) *Intervals between prunings.*

(*i*) *Intervals of about 1½ years.*

This experiment now covers 5 years. Results in mds. tea per acre have been :—

	date of pruning.		date of pruning.		Annual pruning in Dec. for comparison.
1930	May 10th. 1930	5·31	July 31st. 1930	4·59	10·19
1931	unpruned ...	11·74	unpruned ...	11·85	13·27
1932	Dec. 1st. 1931	12·87	Dec. 1st. 1931	13·37	13·11
1933	May 10th. 1933	7·29	July 31st. 1933	7·02	12·42
1934	unpruned ...	14·32	unpruned ...	15·57	12·35
		51·53		52·40	61·34

There is no significant difference between pruning in May and pruning in July. The losses in the years (1931 and 1933) when pruning in the growing season are great compared to annual pruning, and these losses have been, so far, a long way from being made up when the tea is unpruned. The five years, over which comparison extends, does not cover two complete cycles.

We can however select two cycles of 3 years to compare with annual pruning.

	Pruning at 18 months intervals		annual pruning.	loss from rains pruning average.
	May.	July.	December.	
1930 to 1932	29·92	29·81	36·57	6·55
1932 to 1934	34·48	35·96	37·88	2·66

The loss from rains pruning is becoming much smaller. Here again it must be assumed that nitrogen supply finally regulates crop, and in the long run the total crop may be about the same whenever the tea is pruned.

Pruning at intervals of two years.

Crops in mds. tea per acre have been :—

Pruning dates.	April 7th. 1930 " " 1932 " " 1934	June 10th. /30 " " /32 " 19th. /34	Sept. 9th. /30 " " /32	Annual pruning December.
1930	6·11	4·76	6·41	10·19
1931 unpruned	11·91	11·42	13·24	13·27
1932	8·21	6·28	7·78	13·11
1933 unpruned	14·75	14·45	15·60	12·42
1934	8·24	7·12	8·93 *	12·35
	49·22	44·03	51·96	61·34

* In 1934 these plots were actually pruned on October 30th. In the above table, crop to September 9th only has been entered to allow fair comparison of effect of pruning date.

The June pruning has done particularly badly. June 10th happened to be a bad time for pruning both in 1930 and 1932 when pruning was followed by bad hot weather. Pruning at the

peak of the second flush also probably is undesirable and in 1934 the June pruning was delayed till after the big second flush.

Both the April and September pruning also compare badly with annual pruning in December, though not quite so badly.

Here we can select four two-year periods covering complete pruning cycles for comparison.

Crops in mds. tea per acre per 2 years.

	alternate year pruning.			annual pruning	average. loss from pruning in growing season
	April	June	Sept.	December.	
1930 and 1931	18·02	16·18	19·65	23·46	7·51
1931 ,, 1932	20·12	17·70	20·92	26·38	5·47
1932 ,, 1933	22·96	20·93	23·48	25·53	3·14
1933 ,, 1934	22·99	21·51	24·53	24·77	1·74

The rate of decrease in loss from pruning in the growing season is marked. It will be observed that since 1931, the two-year totals are rising with the pruning in the growing season at two-year intervals and falling with annual December pruning. Quite possibly the loss to-date will be made up in the future. It must however take a long time before the loss is recovered. From pruning in the growing season an immediate loss is certain, but where crop is not wanted it may prove a convenience having regard to labour supply, and may be looked upon as a method of conserving nitrogen for future use.

Pruning in April soon after the big first flush is taken, when labour is in over-supply, is a time of practical convenience. The lull after the June rush, also, is a convenient time.

Pruning on September 9th is a practical impossibility. In 1934 it was delayed till October 30th and in future will be performed at about that date or a little later as soon as crop begins to fall off : this also will be a convenient date.

(*c*) *Effect of Cleaning-out.*

Here we have two sets of plots to compare.

(*i*) Annual pruning in December.

Crops in mds. tea per acre.

	cleaned out	cut-across	loss	loss per cent.
1929	8·66	8·31	0·31	4·0
1930	10·19	9·85	0·34	3·3
1931	12·28	11·07	1·21	9·8
1932	13·11	10·40	2·71	20·6
1933	12·42	10·06	2·36	19·0
1934	12·38	10·24	2·14	17·3

Losses from neglect of cleaning out are almost negligible for the first two years. The tea then needed little cleaning out; it was cut to 8″ in December 1925 and pruned very cleanly in December 1926 and 1927. On old high tea, failure to clean out probably would show loss in crop in the first year.

The losses from cleaning out are ascribed mainly to the leaving of *banjhi* shoots on the bush, which delays the coming away of other shoots. The leaving of snags must eventually cause damage to frames, but there is little apparent damage from this cause yet. Although the bushes not cleaned out are full of dead twigs and snags which are rotting, the rot has not yet caused serious damage to the main stems.

Here too the taking of smaller crops would be expected to save nitrogen and so cause relative improvement of the bushes, and since 1931 there have been very small reductions in the losses from failure to clean out. In this case however the loss already made is not expected to be regained, since the cause of gain probably will be counterbalanced by reduction in the efficiency of the bushes due to damaged frames.

In 1934 as in previous years the loss from failure to clean out falls most heavily on the earlier months; after August there is little loss.

mds. tea per acre.

	to end May	June	July	Aug.	Sept.	Oct.	Nov.	Total
cleaned out ...	0·42	1·68	2·13	2·08	2·41	2·65	0·98	12·35
not cleaned out ...	0·23	1·07	1·58	1·65	2·22	2·59	0·90	10·24
Loss ...	45%	37%	26%	21%	8%	3%	8%	17%

(*ii*) Alternate year pruning in April.

mds. tea per acre.

	cleaned out	cut-across	loss.
1930	6·11	6·12	0·01
1931 (unpruned)	11·92	10·49	1·43
1932	6·66	6·58	0·04
1933 (unpruned)	14·75	12·45	2·30
1934	8·24	7·78	0·46

As with the tea pruned in December the loss from failure to clean out was negligible in 1930.

Both in 1931 and 1933 the loss was great, and this loss is again ascribed to the leaving of *banjhi* shoots.

In 1932 and 1934 after the tea has been unpruned the loss is little or nothing : even the loss in 1934 is not significant, having regard to the calculated error of the experiment.

When tea is pruned on two-year-old wood after having been unpruned, the originally *banjhi* shoots have either come away or become smothered and died, while the relatively heavy pruning leaves very few *banjhi* shoots.

The loss in 1934, although not statistically significant, may be real; since in the case of this tea pruned at intervals of 2 years, the frames on which the relatively heavy snags have been left have suffered more damage. Here there is no sign of decreasing loss from failure to clean out, and it is considered that failure

to clean out is already reducing the efficiency of the bushes as nitrogen-using leaf producers.

Effect of Time of Cleaning-out.

In order to take full advantage of the benefit of early pruning, it has been suggested that a garden should first be pruned at a rapid rate by merely cutting across without any cleaning out, while cleaning out should follow later. In 1932 only three pairs of plots were available for a trial of the effect of an interval between cutting across and cleaning out. The result showed that the loss due to an interval of 52 days between cutting across and cleaning out was certainly very small, but the accuracy of the experiment was not sufficiently great to enable the actual loss to be measured.

Starting in 1933 the experiment was repeated on 18 plots of previously very even tea enabling 3 trials to be made, each repeated on 6 plots.

Plot-set No. 1 was pruned cleaning out at the same time on the date set down below. Plot-sets 2 and 3 were cut across at the same height, without any cleaning out, on the same day, and cleaned out at the later dates set down below.

1933.

plot-set	mds. tea per acre.
1. Pruned with cleaning out January 5th ...	11.83
2. Cut across Jan. 5th, cleaned out Feb. 16th ...	11.56
3. ,, ,, ,, ,, ,, ,, March 31st ...	9.48
Significant difference ...	0.25

1934.

plot-set	mds. tea per acre.
1. Pruned with cleaning out 7th December ...	13.06
2. Cut across 7th Dec., cleaned out 25th Jan. ...	12.82
3. ,, ,, ,, ,, ,, ,, 7th March	11.71
Significant difference ...	0.47

In both years the short delay of seven weeks before cleaning out (plot-set 2) produces a negligibly small loss in crop.

In 1933 cleaning out on plot-set 3 was delayed till the peak of the first flush. At this time bushes were in full leaf and cleaning out appeared an impossibly difficult task. It was, however, done as well as seemed possible, with the result that the emptied bushes did not fill up again during that season and consequently a very great loss of crop was observed. It is clear therefore, that cleaning out must be completed before the first flush comes through.

In 1934 the bushes of plot-set 3 were still very empty and required little cleaning out. Only a little *banjhi* growth was removed on March 7th. These plots yielded relatively poorly early in the season, but became filled up as the season progressed and by October were yielding practically as well as plot sets 1 and 2.

A date in early March will be persisted with on these plots.

The indications to-date are that though loss in crop probably increases with increasing interval between cutting across and cleaning out, yet the loss is negligible for an interval of seven weeks, and is probably of very little practical importance so long as completed before the first flush comes through. About the first week in March probably may be taken as the latest date for cleaning out.

Though it generally costs more (say another Rs. 3/- per acre) to prune in two operations instead of one, the advantage in increased crop, nearly all of which falls on the second flush is believed generally to pay in Assam; particularly where, as at Borbhetta, there would be insufficient remunerative work for the labour in the cold weather if time were not spent on pruning.

At Borbhetta it is now customary to use all hands capable of using a knife to complete the first cut-across soon after the end of December. Women alone carry on with cleaning-out, except for the incapables who are forking. The men meanwhile complete the cold-weather cultivation and then help finish off the cleaning out by about the end of February. Manuring, infilling, drain cleaning, line repairs, roads, fences and odd jobs barely provide enough work from then until plucking is in full swing.

At Borbhetta, including all men, women and children, sirdars and chowkidars we have 120 coolies for a fenced area of 102 acres, which includes 63 acres (as usually measured) of tea in plucking, the balance being roads, drains, paths, nurseries, small seed gardens, land being cleared and levelled for planting, land under Tung, houses, etc.

For accurate plucking of high-yielding areas under experimental conditions in the rains, we cannot do with less; but labour is excessive in the cold weather. Where labour is much less plentiful, pruning in two operations may not be possible.

Trial of different methods of heavy pruning.

The Kharikatia section at Borbhetta was first pruned after two years in the soil, by cutting across at 18″ without any centring or spacing out. By 1927 when 10 years old, it had become very high; but, although not receiving any nitrogen as manure, was still in good condition as indicated by a yield of 10 mds. per acre. In early 1928, strips, each 15 bushes wide, were alternately collar-pruned and cut to 18″ from the ground. The yield of each strip had been practically the same for 6 years previous to cutting.

From 1928 to 1933, manure mixtures supplying 40 lbs. nitrogen per acre were applied annually to all plots.

In 1933 the manure application was doubled, for all plots, but was not applied until July.

The yields since heavy pruning have been :—

	mds. tea per acre.		mds. tea per acre.
1928 collar pruned	*nil*	cut at 18″ from ground ...	2·57
1929 cut at 8″ from ground ...	4·31	,, ,, 20″ ,, ,, ...	8·02
1930 ,, ,, 14″ ,, ,, ...	4.16	,, ,, 22″ ,, ,, ...	8·59
1931 ,, ,, 18″ ,, ,, ...	7·14	,, ,, 23″ ,, ,, ...	10·70
1932 ,, ,, 20″ ,, ,, ...	8·16	,, ,, 24″ ,, ,, ...	10·24
1933 ,, ,, 20½″ ,, ,, ...	9·31	,, ,, 24½″ ,, ,, ...	11·00
1934 ,, ,, 21″ ,, ,, ...	11·45	,, ,, 25″ ,, ,, ...	12·84
Total ...	44·53		63·96

The loss in crop from collar pruning as compared to medium pruning is still significant, even in the seventh year after the cutting back, and there can be little doubt that the collar pruning has caused loss in quality over a long period also.

Reduction in height is a necessity, at long intervals, in order to allow accurate and rapid plucking. Diseased parts of frames (often caused by inefficient ordinary pruning but more commonly by heavy pruning) also must be removed.

Any cutting beyond what is necessary to effect these two objects should be avoided, whether on old or on young tea, and collar pruning should be reserved for cases (generally a small percentage of any area) where frames are so rotten that nothing can be left. The appearance of vigour following heavy cutting is deceptive, and lasts only till the old size of the bush is nearly made up, after which the bush is weaker and more stunted than if it had never been cut. Cutting back should never be referred to as "renovation". Renovation should seek to put right what has been wrong; generally failing food supply, for which heavy cutting is no remedy. Though the stimulus of pruning may occasionally produce increased crops for a time, the following deterioration is generally the more certain on that account. Where the trouble is old age, heavy cutting only hastens the end.

The medium-pruned bushes still carry a number of unhealed wounds where cut on heavy wood, but should any trouble arise at these wounds, they are sufficiently high in the bush to be removed without much loss. Many of these wounds were caused by unnecessary removal of heavy central stems, at the time of cutting back. This is a common mistake which should be avoided in future. A live stem in the centre, is greatly preferable to a large wound which may not heal, and the emptied centre either remains empty, or fills up with new growth which should have gone to increase width.

Of the collar-pruned bushes 5% died, many have grown very weakly, and a number have come away from one side only,

leaving a wound which cannot be pruned away, if diseased, and has little chance of healing. Many of the collar-pruned bushes are now splendid bushes again, and they are 4″ lower than the medium pruned bushes, so that they can be cropped fully for a longer time before they next have to be reduced in height; but the average crop is not expected to be any better than that of the medium-pruned bushes during the time when both are in full yield.

PLUCKING.

Experiments on differences in severity of plucking.

The Bazalony Plots at Borbhetta.

These plots were all cut back to 22″ in November, 1932, and all plucked alike since then, leaving 12″ of new wood in 1933, and 10″ in 1934. When under the same plucking in 1933 and 1934, yields differed little in spite of the great differences in plucking previous to 1933.

Style of plucking 1927 to 1932	mds. tea per acre.	
	1933	1934
4″ to janam	4·47	10·61
6″ „ „	4·43	10·90
8″ „ „	4·42	10·98
10″ „ „	4·59	11·12
4″ then 1 big leaf then janam	...	11·14
6″ „ „ „ „ „	4·58	11·23
8″ „ „ „ „ „	4·23	10·93
3 leaves then 2 leaves, then 1 leaf then janam	4·72	11.45

None of these differences can be accounted significant, but the indications are that the differences in severity of plucking for 6 years before cutting-back, have made very small differences to the yield of the tea after cutting back.

These plots were not laid out to secure the greatest accuracy of statistical comparison. Experiments on severity of plucking will be transferred, in 1935, to the Rajghur plots which are now in condition to yield accurate comparisons. These new experiments will include trials of increasing early and late crops at the expense of rains teas.

The Bazaloni plots previously used for this experiment are already very even; but will be plucked alike, and treated alike in other respects for one or two more years, and then used for other experiments.

New experiment on differences due to differences in fineness of plucking.

Doolia Block 2, at Borbhetta.

This experiment was designed mainly to obtain information on the influence of differences in plucking on market prices; but the yields also are of great interest and are here recorded.

The tea used comprised 64 plots of the dark-leafed Doolia variety of tea which was planted in cold weather 1928/1929, and is still far from full yield. It was divided into 8 blocks of 8 plots each: each of eight different pluckings being repeated once in each of the eight blocks.

All plots were plucked alike up to the 21st July. Differential plucking commenced on July 27th. During August and September leaf from 7 of the different plot-sets was manufactured separately on 8 occasions.

It was particularly desired to determine whether *banjhi* leaf was any better or worse than growing shoots. Three of the eight plots were therefore plucked in two operations; first, to take such growing shoots as were required for experiment, all *banjhi* shoots being left on the bushes; and second, to take the *banjhi* shoots. The mixed *banjhi* leaf from these 3 plots, about half

fine, and half very coarse, was manufactured separately. Yields of all plot-sets were practically the same when under similar treatment, both in 1933 and in 1934 up to July 21st.

Plucking was on Thursday in each week.

Yields during August and September were :—

plot-set.	Style of plucking.	plucking orders given	how broken back	mds. tea per acre		
				growing shoots	banjhis	Total
1	very coarse	all shoots of 3 leaves and bud, nothing else, double banjhis plucked separately.	to janam (little necessary)	3·76	1·02	4·78
2	coarse	everything down to janam	unneces-sary	3·83	.....	3·83
3	medium	all shoots of 2 leaves and bud, nothing else, double banjhis plucked separately.	to janam	2·35	0·87	3·22
4	fine (a)	very big shoots of one and a bud, all shoots of 2 leaves and a bud and single banjhis.	to original level	2·63	.....	2·63
5	„ (b)	do.	to janam	2·63	.....	2·63
6	„ (c)	do.	not at all	2·62	.....	2·62
7	„ (d)	do. but banjhi shoots left on bush.	to janam	2·33	—	2·33
8	superfine	all shoots of 1 and a bud, all shoots of 2 and a bud banjhis plucked separately.	do.	2·26	0·43	2·69
		Significant difference	.....	.....	.....	0·14

Crop decreases rapidly as fineness of plucking increases. It is of course not at all certain that such big differences will be maintained.

Except that crop is decreased a little by leaving *banjhi* shoots on the bushes, there is no difference in crop during this first period caused by the different degrees of severity of breaking back.

At the end of September, manufacturing experiments ceased; but the differential plucking was carried on except that all plot-sets were plucked in one operation; the plucking systems becoming as below. Plucking was still at weekly intervals.

plot-set.	Style of plucking.	plucking orders given.	how broken back.	mds. tea per acre October and November.
1.	very coarse	All shoots of three and a bud, and double or treble banjhis	unnecessary ...	3·30
2.	coarse	everything taken, down to janam, except shoots of one and a bud ...	,, ...	2·75
3.	medium	shoots of two and a bud; and double banjhis only	to janam ...	2·58
4.	fine (a)	very big shoots of one and a bud; all shoots of two and a bud, and single banjhis ...	to original level	2·30
5.	,, (b)	as 4	to janam ...	2·06
6.	,, (c)	as 4	not at all ...	1·71
7.	,, (d)	as 4: but all banjhi shoots left on bush till they came away, when broken back as far as possible.	to janam, on growing shoots. Breaking back of woody shoots of banjhis after coming away was irregular...	1·21
8.	superfine	all shoots of one and a bud as far as practicable; all shoots of 2 and a bud; and single banjhis ...	to janam ...	2·08
			Significant difference :—	0·16

During this latter period the gains in crop from increased coarseness of plucking are still very significant, but are not as great as in August and September. Presumably, soil and bush are more depleted of reserves of food where larger weights of leaf are taken.

Breaking back (plot-sets 4, 5 and 6) is now causing significant differences in crop. On the heavily broken-back plot-set 4, at the end of the season, leaves on the bushes were thin and small, and bushes looked debilitated, but they had given more crop than the normally broken-back plot-set 5. Plot-set 6 which was not broken back at all was very leafy and looked dark green and healthy, but had lost crop significantly.

The effect of leaving *banjhi* shoots unplucked till they came through (plot-set 7) was to leave extremely healthy-looking bushes, but to lose crop very heavily. When the *banjhi* shoots did come away they yielded short, fat shoots suspected to give quality; while if there is anything in the slow growth theory, the general slowing-up of growth due to the presence of *banjhi* shoots on the bush, possibly may cause these plots to show improved quality.

In 1934 leaf from plot-set 7 was not manufactured.

In 1935 leaf from all these plots will be manufactured separately after plucking as in October and November 1934.

The order, to break back a shoot plucked after coming away from a *banjhi* bud, could be obeyed strictly only by the men or a few strong-fingered women. The shoots had become very hard and fibrous and were generally broken back only a short distance leaving torn, rather than broken, stems above the general level. These seldom yielded a plucking shoot again during the season.

The "superfine" plucking on plot-set 8 did not yield any less crop than the "fine" plucking (similarly broken back) on plot-set 5. It was of course impossible to get all the very small shoots of one and a bud plucked on plot-set 8, but the counts showed very distinctly finer leaf from plot-set 8 than from plot-set 5, while the appearance of the made tea was distinctly superior.

	Average leaf-counts, per cent.			
	"Superfine" plucking		"Fine" plucking	
	by numbers	by weight	by numbers	by weight
One and a bud ...	28·7	18·2	10·1	6·5
Two and a bud ...	68·6	79·2	76·0	83·7
Three and a bud ...	1·2	1·7	2·8	3·6
Single banjhis ...	0·5	0·2	5·9	2·5
Double banjhis ...	1·0	0·7	5·2	3·7

The average weight per shoot of all shoots plucked was :—

"superfine"	...	0.24 grams.
"fine"	...	0.32 ,,

There was, then, a real difference between the two styles of plucking; yet, in this case, the finer of the two pluckings gave as much crop as the coarser. Possibly, the removal of shoots of one and a bud stimulates growth.

In 1934 the effect of this very fine plucking on valuations was not very encouraging. Liquors appeared to gain some quality at the expense of strength or colour, while the better appearance seemed of little account. The 1934 manufacturing trials were made in the rains. It will be interesting to observe results during the second flush in 1935.

For a complete account of the results of manufacturing experiments on these plots see Report of the Chemical Branch.

CULTIVATION.

1. The Singlo and Matelli Blocks at Borbhetta.

These experiments are on single plots only, of ⅓rd acre each; but, each plot has been plucked as five sub-plots since 1925, and as soil variation occurs in patches, generally of less extent than a single sub-plot, and shows no regular gradation in any direction, the agreement (which is generally very good) among the five sub-plots of any big plot, may be taken as an indication of general accuracy; though in a case (*e.g.*, plot 85) where "bad patches" occur, and the agreement among the five sub-plots is bad, the results recorded are below the true average.

The treatments described have been continuous since 1922. The tea had been cut back to 12″ in the cold weather 1921/1922, and was only slowly brought up. In the early years of the experiment therefore bushes were small, affording little cover, and any increase in the efficiency of jungle suppression increased crop. As the tea grew and afforded better cover the effect of cultivation became less, till by about 1929 it became clear that cultivation in the sense of soil-stirring, whether deep or shallow, had no good effect, and that cultivation is valuable

only up to the point at which weeds are suppressed. A further five years of similar treatment has rendered this conclusion even clearer.

Yields over the past ten years have been :—

	Plot No.	Cultivation.	Average 5 years 1925 to 1929	1930	1931	1932	1933	1934	Average last 5 years 1930-1934
1916 planting Singlo	78	1 deep hoe, 1 fork, 6 light hoes	11·1	13·1	14·2	12·3	12·1	13·2	13·0
	79	1 fork, 7 light hoes	10·8	11·9	13·9	11·9	11·5	12·3	12·3
	80	1 deep hoe, 1 fork, 6 light hoes, trenched in 1921 and 1922	10·0	13·1	14·0	12·0	11·5	13·3	12·8
	81	1 deep hoe, 1 fork, 4 light hoes	7·7	9·8	12·3	10·6	10·4	11·8	11·0
	82	1 deep hoe, 1 fork, 11 light hoes	11·5	13·1	14·3	11·6	10·9	13·0	12·6
1918 planting Singlo	83	1 deep hoe, 1 fork, 3 light hoes and 8 rounds scraping	9·4	12·3	14·0	11·2	11·2	12·6	12·5
	84	1 deep forking, and 2 light forks all with long-handled English digging forks	3·1	4·1	4·9	4·3	5·2	4·1	4·5
	85	1 deep hoe, 1 fork, 6 light hoes with flat hoes ..... —	7·0	9·5	11·3	10·0	10·2	11·2	10·4
	86	1 deep hoe, 1 fork, 6 light hoes with fork hoes	7·8	11·2	12·4	10·7	11·5	11·8	11·5
1917 planting Matelli	87	1 deep hoe, 1 fork, 11 rounds scraping	10·3	10·9	11·2	8·6	11·1	12·0	10·8
	88	1 deep hoe, 1 fork, 1 light hoe in June, 1 round sickling* in September but extra manure to the value of 4 light hoes	7·7	11·0	14·0	14·8	15·5	18·1	14·7
	89	1 deep hoe, 1 fork, 6 light hoes	10·0	11·3	12·3	9·6	11·6	12·2	11·4
1916 planting Matelli	92	1 deep hoe, 3 forks around bushes, no light hoeing	6·2	7·5	8·9	8·9	10·9	11·4	9·4
	93	1 deep hoe, 1 fork, 6 light hoes	10·9	11·7	12·4	10·6	13 0	13·3	12·2
	94	1 very deep hoe to 18" 1 fork, 6 light hoes	10·4	11·3	12·7	10·7	12·9	13·1	12·1
	95	1 deep hoe, 1 fork, sickled twice in rains, no light hoe	4·5	5·6	6·9	7·1	8·3	8·7	7·3
	96	1 deep hoe, 1 fork, 3 light hoes before mid-June then 3 rounds forking	10·4	12·4	13·4	12·2	13·5	14·3	13·2

A "fork" means a hand "tully" around the bushes.

*Except in 1932, 1933 and 1934 when it was quite unnecessary.

The general theory then is that the main object of cultivation is to suppress weeds, which do harm by slowing down the formation of soluble forms of nitrogen, in which forms, only, a plant can take its food.

It is a corollary of this theory that cultivation, by causing soil nitrogen to be used, must exhaust the soil; and plots which in early years yield poorly, through inefficient cultivation, retain richer soil, and should show greater relative improvement in later years.

This is illustrated by the following sets of plots.

1916-planted Singlo.

Plot.	Cultivation.	Average yield mds. tea per acre.		
		1925 to 1929.	1930 to 1934.	Gain.
82	11 light hoes	11·5	12·6	1·1
78	6 „ „	11·1	13·0	1·9
81	4 „ „	7·7	11·0	3·3

1916-planted Matelli.

93	6 light hoes	10·9	12·2	1·3
92	3 rounds forking around bushes and sickled between bushes twice. No hoeing ...	6·2	9·4	3·2
95	Sickled twice only	4·5	7·3	2·8

The most interesting comparison is that between plots 88 and 89 among the 1917-planted Matelli tea.

These two have been run at the same cost, as nearly as can be estimated.

Plot 89 gets normal cultivation and normal manuring : plot 88 gets only one light hoe annually, but 40 lbs. per acre more nitrogen annually as manure.

The results have been :—

Plot.	Cultivation and manuring.	Average yield.		
		1925 to 1929.	1930 to 1934.	Gain.
89	6 light hoes and 40 lbs. nitrogen...	10·0	11·4	1·4
88	1 light hoe and 80 lbs. nitrogen ...	7·7	14·7	7·0

In early years plot 88 disappeared under tall grass and yielded poorly. Gradually the manuring helped shallow rooted weeds (dhub grass and ageratum) to replace thatch, and latterly such thick bushes have grown that at the end of 1934 nothing grew under them except a few ferns.

In 1934 the comparison is :—

6 light hoes and 40 lbs. nitrogen ... 12.2 mds. tea per acre.
1 light hoe and 80 lbs. ,, ... 18.1 ,, ,, ,, ,,
Difference ... 5.9 ,, ,, ,, ,,

A difference of 6 mds. per acre is much greater than is due to the extra 40 lbs. nitrogen and can only be ascribed to the conservation of nitrogen in the soil in early years when the soil was infested with bad weeds. It was equivalent to the leaving of land under grass in an ordinary rotation in British agriculture.

It will be observed that in 1933 the comparison was :—

1 light hoe and 80 lbs. nitrogen ... 15.5 mds. tea per acre.
6 light hoes and 40 lbs. ,, ... 11.6 ,, ,, ,, ,,

Difference ... 3.9 ,, ,, ,, ,,

When the heavily manured tea is pruned and cleaned out, it affords only light cover and some weeds do get away before the one light hoe is applied in early June.

In 1933 the very quick growing "Mexican groundsel", *Erechthites Valeriane foliade* DC, was above the bushes before this hoe was got in. In 1934 complete absence of rain in March caused this weed to make a slower start, and a slightly earlier

light hoe was in time to allow the thickening cover of leaf on the bushes to suppress further growth of all weeds.

The comparison of these two plots illustrates possibilities of cheapening production, by producing the crop allowed under the Restriction Act, from a smaller area of well-manured tea, requiring labour in the rains, only for plucking, rather than from a larger area of poorer tea requiring a much larger labour force.

Meanwhile the area not required could be left to grow and improve, with as little cultivation as will enable the tea to get thick enough to need no further attention other than an occasional cutting of creepers.

To get sufficient cover, yield must be raised to about 15 mds. per acre. It is not advisable, or possible, to raise tea from say 8 to 15 mds. at once.

Roughly the manuring proposed on, *e.g.*, unmanured tea giving 8 mds. per acre would be :—

	lbs. nitrogen per acre.	Probable yield per acre.
1st year	40 lbs.	9½ mds
2nd ,, ...	40 ,,	10½ ,,
3rd ,, ...	60 ,,	12 ,,
4th ,, ...	60 ,,	13 ,,
5th ,, ...	80 ,,	14 ,,
6th and following years ...	80 ,,	15 ,,

With the yield gradually increasing in this manner, no loss of quality would be expected on the present evidence ; but this point will be clearer after experiments commencing in 1935. Such a policy could be recommended of course, only if the restriction scheme is expected to persist. If it is expected to be of short duration, expenditure on manuring should be limited to that necessary to produce the crop required; since, though yield will fall off, it can be raised rapidly, when required. In the meantime, if the principle of production from reduced areas is approved, the manuring necessary to produce the crop required

could be limited to the area which will be kept if the restriction scheme is of long duration.

Other properly replicated, more accurate experiments support the conclusions concerning the inutility of soil stirring.

(2) *Trial of hoeing against scraping* (cheeling).

Five plots are devoted to each treatment. Previously to 1932 both sets had been treated alike.

In 1930 and 1931 when under the same treatment yields had been in lbs. leaf per plot.

Plot-set 1.			Plot-set 2.		
1930.	1931.	Total.	1930.	1931.	Total.
238	259	497	239	260	499
232	241	463	224	248	472
271	300	571	245	272	517
206	238	444	217	247	464
222	247	469	231	260	491
1159	1285	2444	1156	1287	2443

During 1932, 1933 and 1934, plot-set 1 received 5 rounds light hoe, while plot-set 2 was "cheeled" whenever plot-set 1 was light hoed.

Neither set of plots receives a deep hoe or any cultivation beyond that described. Yields have been :—

plot-set 1. hoed				plot-set 2. cheeled			
1932	1933	1934	total	1932	1933	1934	total
201	250	264	715	208	257	252	717
195	242	248	685	190	231	232	653
234	290	283	807	229	286	292	807
189	232	234	655	204	253	246	703
184	234	231	649	196	257	256	709
1003	1248	1260	3511	1027	1284	1278	3589

There has been no significant difference in yield to date whether the soil is stirred by hoeing, or weeds are suppressed merely by surface scraping.

(3) An area of good tea was selected for trials of the effects of reducing cultivation to a minimum on tea affording heavy cover. The tea was good to start with, but to maintain and increase this cover, heavy manuring is necessary. In 1932 and 1933, 60 lbs. nitrogen per acre were given, and 70 lbs. in 1934, while it is probable that dressings must be increased in the future, as the original richness of the soil becomes worked out.

It should be emphasised that results like these shown below will not be obtained except where the cover of tea is thick.

	plot-set	mds. tea per acre.		
		1932	1933	1934
Normal cultivation, a deep hoe and 6 light hoes.	1. deep hoe the day after pruning to bury prunings as is usual. ...	15·5	18·6	19·4
	2. deep hoe the day before pruning, to leave prunings unburied. ...	15·1	17·8	18·4
reduced cultivation.	3. 5 light hoes only, in 1932 4 light hoes only, in 1933 and 1934. ... No deep hoe	15·0	16·8	18·1
	4. sickled only, no hoeing at all.	14·1	16·6	18·1
	5. hand weeded only. ...	15·8	19·5	21·0
	6. hand weeded as 5; but a deep hoe to bury prunings in addition. ...	14·7	17·6	19·2
	Significant difference ...	0·67	1·14	1·11

The difference between plot-sets 1 and 2, burying prunings against leaving them unburied, is not definitely significant; but

is sufficient to be suggestive that there is some loss from failure to bury prunings, particularly as the difference is increasing annually.

Plot-sets 2 and 3 differ in that plot-set 3 receives no deep hoe and also less light hoeing than plot-set 2. In 1932, 5 light hoes were practically as good as a deep hoe and 6 light hoes. In 1933 the dropping of a round of light hoe, produced a loss on the verge of significance. In 1934, although crops were not greatly increased, the cover was better, and 4 light hoes prove practically as good as 6 light hoes and a deep hoe.

Plot-set 4 has not been cultivated at all since 1931, but is sickled whenever weeds are high enough to grasp. In each season the sickling was performed four times, but probably much less will be necessary in 1935. Jungle never became heavy even in 1932, but there was sufficient to reduce crop significantly compared to normal cultivation (plot-set 1) in 1932 and 1933. There was however no loss in 1934, (when cover was heaviest and jungle was at a minimum) compared to either plot-set 2 or plot-set 3. The soil, which is never disturbed by implements, appears to be in good physical condition. There is danger of caterpillar pests, and of white ant hills, otherwise it is expected that cultivation on these plots may be reduced in future, without harm, to practically nothing.

Plot-set 5 also gets no cultivation at all in the ordinary sense, but 4 rounds of hand weeding per season keep it absolutely clean of weeds. In 1934 it is significantly better than all other plot-sets, in spite of the failure to bury prunings.

Plot-set 6 provides the most interesting and direct comparison with plot-set 5. Their treatments are identical except that plot-set 6 gets an ordinary deep hoe each cold weather. In spite of the advantage of burying prunings on plot-set 6, the effect of this deep hoe is a significant loss of crop in each year. The reason is not far to seek. The uncultivated plots develop a mass of rootlets near the surface. After the deep hoe, the surface of the soil is covered with cut rootlets. These can no

longer provide either food or water to the bush. Other roots not cut, but disturbed and lying in loose soil, have reduced power of obtaining water from a soil of low water content. In consequence up till May or even June the deep hoed plots look yellow and poor, while the plots not deep hoed are green, healthy, and flushing. A study of the crops over the season shows how great was the loss of early crop after the deep hoe.

	mds. tea per acre.		
	to end May.	June and July.	1st. Aug. to end of season
hand weeded only ...	1·29	6·86	12·83
hand weeded plus deep hoe	0·75	5·82	12·61

All the loss from deep hoeing occurs in the early part of the season. After July, crops are alike with and without the deep hoe.

Losses from deep hoeing of tea light hoed during the season would not be as great, since there are less roots so near the surface; but it is suggested that roots in the rich soil near the surface may be of great advantage.

All the evidence to-date therefore supports the theory that cultivation is necessary to suppress weeds; and further suggests that any disturbance of the roots, beyond what is necessary to suppress weeds, is not only of no value, but may do harm.

This theory of cultivation which we have advocated for a number of years is now receiving support from workers in other countries and on different soils and crops. For example the Report for 1933 of the Rothamsted Experimental Station contains the following results.

(1) Sugar beet (p. 23).

"As shown last year, nothing was gained by giving more cultivation than is needed to keep down weeds."

(2) Barley (p. 30).

"A number of experiments have been made on different methods of seed-bed preparation, including shallow and deep ploughing and rotary cultivation, each in conjunction with spring harrowing rolling and top-dressing with sulphate of ammonia. No significant differences in yield of grain were observed between any of the treatments, and the choice of the different methods would apparently be dictated by their relative cost and convenience.

"Neither rolling nor harrowing increased the yield of grain.

"The conditions however were unusual in that sulphate of ammonia had no effect on the yield of grain. On the other hand the yield of straw was increased by the addition of nitrogen. The response to nitrogen varied according to cultivation. Rolling increased it."

The Rothamstead soil is a very heavy one and it is interesting to notice that similar results have been obtained to those from the light soil of Borbhetta.

The above words may well be applied to the case of tea. Cultivation methods should be "dictated by their relative cost and convenience;" and a recognition of the object of cultivation, *i.e.*, the suppression of weeds, should lead to some economy on most gardens.

It is interesting that at Rothamstead the only "cultivation" to yield any effect at all (apart from weed-suppression) was rolling, or *compacting* of the surface soil, which increased the

response to nitrogen of the straw. In the Rothamsted report no explanation of this result is given. It may be surmised that the rolling increased the water content of the surface soil in the spring, and allowed roots to feed where was the top-dressing of sulphate of ammonia.

It is very interesting also that deeper cultivation did not increase the growth, even of the straw ("leaf"). Apparently, either its root-range was not increased, or no benefit was secured, if the root-range was increased.

It will be observed also in the experiments on tea at Borbhetta and Tulsipara, that deep cultivation has no good effect.

The idea that depth is necessary for our cold-weather cultivation of tea can be abandoned with safety and economy. On most gardens of low to moderate yield where surface cultivation has been neglected in the rush season, some form of cold-weather cultivation is necessary to clean the land, while prunings also should be covered. Any method found efficient and convenient for this object is good.

At Borbhetta the "one-chop, cheel, and bury hoe" does as well as anything we can devise. The one-chop (about 6″ deep) opens a shallow trench, into which surface weeds and prunings are scraped, to be covered by the next chop. The neighbourhood of the collar is avoided by the hoeing men ; that is dealt with by the forking women who are instructed to remove weeds, disturbing the soil as little as possible.

MANURING.

Soil Acidity and Liming.

Application of large quantities of lime.

Bushes were planted at Tocklai in 1922 on plots previously treated with 400, 300, 200, 100 and 50 maunds crushed limestone per acre, and no lime, respectively.

All plots now show progressive falling off in appearance according as the lime dressing was heavier. On the most heavily limed plots only a few bushes survive. Where the original bad effect of the liming was corrected three years after liming by addition of equivalent quantities of sulphur, such bushes as had survived the three years recovered, and still exhibit normal growth.

Application of small to moderate quantities of lime.

The Betjan plots at Borbhetta.

On these plots the effects of quantities of lime varying from 600 to 3,200 lbs. per acre were compared with those from unlimed plots. The lime was applied early in 1922, and up to 1924 the effect of lime was to cause a very small decrease in crop. In 1925 Arhar was sown. On unlimed plots practically no growth was obtained, while good crops, increasing as the lime dressing increased, were obtained from all the limed plots. In that year, the greater the crop of Arhar obtained, the less was the crop of tea. The Arhar was trenched in, and in following years, its effect was to increase the yield of tea, but not proportionately to the weight of Arhar.

The lightest liming showed a small benefit on balance, but the heavier dressings showed losses increasing with the quantity of lime applied : the bad effect of the lime more than counterbalanced the good effect of the Arhar as manure.

The whole block was cut back to 22″ from the ground in November, 1931; and in November, 1932, was pruned at 24″ from the ground, all dead wood being carefully removed. In December 1933 it was pruned at 24½ from the ground and again well cleaned out.

Yields over the past five years have been :—

		mds. tea per acre.				
		1930	1931	1932 cutback	1933	1934
Set. 1	No manure at any time ...	7·1	7·8	6·0	9·1	10·8
„ 2	15 mds. crushed limestone per acre in 1922. No other manure at any time	7·0	7·4	6·4	9·1	10·6
„ 3	Rotation of manure without lime ...	11·2	12·2	8·6	14·3	16·5
„ 4, 5, 8, 9, 10 and 11	Rotation of manure with various forms of lime totalling 600 lbs. lime per acre in 1922	11·8	12·6	8·8	14·0	16·7
6, 7 and 12	Rotation of manures with various forms of lime totalling 1,200 lbs. lime per acre in 1922 ...	11·2	12·0	8·1	13·3	15·8
Set. 13	Rotation of manures with crushed limestone in 1922 equal to 3,200 lbs. lime per acre (leaving soil practically neutral)	9·9	10·2	7·1	11·7	14·0

The liming of 1922 has made little difference, but the more heavily limed plots yield less than the unlimed.

It will be observed that these plots are now fully back to their yield before being cut-back (to 22″ only) in November 1931. The recovery was assisted in the case of the manured plots by a manure application supplying 80 lbs. nitrogen, 40 lbs. phosphoric acid and 40 lbs. potash per acre. Little advantage is obtained from manuring bushes immediately after cutting back, but in the following year a heavy dressing to re-grow frames appears to be sound. The small, unmanured bushes are little set back by the cutting, and indeed appear to show a benefit (probably temporary) from the stimulus. Big bushes take a long time to re-grow frames of the old size, unless assisted.

In the fresh series of experiments started in 1930 no significant effect has yet appeared either from a small reduction or

from a small increase of acidity due to light dressings of lime and of sulphur respectively.

1930 treatment	mds. tea per acre.				
	1930	1931	1932	1933	1934
560 lbs. pure lime per acre ...	12·3	12·9	8·8	13·9	16·3
nil	11·8	12·6	8·8	14·2	16·7
400 lbs. ground sulphur per acre ...	12·0	12·8	8·1	14·3	17·3
Significant difference	...	...	0·6	0·7	1·1

The reduced yield from the sulphured plots appeared to be significant in 1932, and was ascribed to increased degree of attack by rim blight, which it was thought might possibly produce improved quality of tea. These three sets of plots were separately manufactured in 1933, with the result that no difference was found between the teas. Both rim-blight, and the "green-fly stunt" were markedly absent in 1933. No manufacturing trials were made in 1934 on these plots.

In 1934 the difference in crop between the limed and the sulphured plots is almost significant.

The work on soil acidity and liming to-date indicate that :—

(1). Moderate doses of lime which still leave soil definitely acid have little direct effect on tea crop. Such doses have been shown to have beneficial indirect effects.

(*a*). By allowing good growth of leguminous crops on soils previously too acid to favour legumes.

(*b*). By increasing the rate of nitrification of organic manures : but this last benefit is generally smaller than could be obtained for the same cost by increasing the dose of readily available nitrogenous manure.

(2). Small applications of sulphur on soils already acid have similarly little effect. On soils insufficiently acid good results have appeared from the use of sulphur to increase acidity on several estates as well as in the previously heavily limed plots at Tocklai.

(3). Lime, whether naturally present, or added artificially, in sufficient quantity to render soil about neutral (non acid) has a definitely very bad effect on growth of tea.

On soils naturally non-acid, we have many records of repeated failure to establish tea, and we know of no case where tea has been successfully established on such soil.

Where the lime has been added artificially, it affects the top soil only; and tea previously established remains good for some time at least. Yield however is reduced, and in several such instances definite deterioration has occurred after some years.

Large quantities of wood ash such as are added to patches of soil where big heaps of timber are burnt after clearing heavy jungle, also leave patches of soil unfit for tea. White-ant teelas are also non-acid, and unfit for tea, though they grow leguminous plants well.

The great majority of good tea soils in North East India have pH between 5.0 and 5.5. Very rarely is tea doing at all well on soil of pH = 6. Experiments with tea seedlings in Java have shown these to do best with soil as highly acid as pH = 4, and some mature tea at Tocklai growing in soil at that acidity is doing as well as similar tea in soil of pH 5.5.

A neutral (neither alkaline nor acid) soil has pH = 7, and the lower the pH the greater is the acidity.

Potash and Phosphoric Acid.

Part of the Tingamira Block—Borbhetta.

A dressing of 40 lbs. nitrogen (195 lbs. sulphate of ammonia) per acre is tried alone and in addition to fourteen different combinations of potash and phosphoric acid against no manure. Each trial is repeated on eight plots selected so that the sum of the yields of each of the 16 sets of 8 plots had been practically the same in 1929 and 1930, and so that one plot of each of the 16 treatments fell into each of the eight different blocks.

Since the preliminary yields are practically the same, application of the analysis of co-variance necessitates very slight adjustment of the final yields as weighed but reduces the estimate of error considerably.

Manures were applied for the first time in March 1931, and were repeated in 1932, 1933 and 1934.

Effect on Crop.

In 1931 all the 15 plot-sets receiving nitrogen yielded alike within negligibly small differences. No quantity of potash or phosphoric acid or both had any effect whatever.

In 1932 a difference of about 5% appeared from the use of nitrogen with potash and phosphoric acid against nitrogen alone, but such difference is within experimental error, and cannot be considered significant.

No measurable effect therefore had appeared within two years from the use of phosphoric acid, potash or both. The bush, of course, cannot grow without potash and phosphoric acid, and analyses of the leaf showed it to be normal in content of potash and phosphoric acid. It must be assumed that for two years the natural soil was able to provide sufficient for the needs of the bush.

In the third year the following results were obtained in lbs. leaf per 720 bushes.

Yields 1933.

	potash lbs. per acre			
	0	15	30	60
phosphoric 0	1196	...	1342	1246
acid 15	1297	1367	1344	1363
lbs. 30	1284	1375	1376	1375
per acre 60	1235	1332	1396	1286
	Significant difference :—			91

It will be observed that in 1933, the third year of continuous manuring, all the plot-sets receiving both potash and phosphoric acid, as well as nitrogen, yield significantly more than the plot-set receiving nitrogen only.

In 1934 results which are in some respects anomalous have been obtained.

Yields 1934, lbs. leaf per 720 bushes.

	potash lbs. per acre			
	0	15	30	60
phosphoric 0	1308	...	1347	1398
acid 15	1341	1437	1375	1472
lbs. 30	1295	1389	1336	1416
per acre 60	1409	1417	1441	1548
	Significant difference =			100

All plots have given an increased crop in 1934 compared to 1933; but the increase is much greater with some treatments than with others.

The plot-sets receiving nitrogen only, have given a very big increase compared to the others, and the effect of this is that compared to the yields from nitrogen alone, only 6 of the plot-sets receiving both potash and phosphoric acid yield significantly

more, while three do not; whereas in 1933 the plot-set receiving nitrogen only, yielded significantly less than all 9 plot-sets receiving potash and phosphoric acid in addition to nitrogen.

This difference between results in the two years must be due to some seasonal factor, which cannot now be guessed.

In last year's report, it was observed when commenting on the relatively low yields in 1933 of the plot-sets receiving 60 lbs. potash "in 1933 (but not in 1931 or 1932) the potash was supplied (for economy) as muriate, which may reduce growth in large doses, though not in small doses. In 1934 the use of the sulphate will be resumed, for safety." 1934 results justify this change. The four plot-sets receiving 60 lbs. potash as sulphate in 1934, are roughly as much above average, as they were below average when receiving 60 lbs. potash as muriate in 1933. Such a result is suggestive of the correctness of the guess made last year. The heavy dose of muriate in 1933 appears to have prevented full use of the nitrogen available in that year, while in 1934 we see the full effect of the 1934 dose, plus that of the unused balance of the 1933 dose. A similar effect is seen on the dark Mesai Manipuri plots (p. 126) where also 60 lbs. potash were applied as muriate in 1933, and as sulphate in 1934.

The sums of the yields for 1933 to 1934, eliminate the effect of this factor.

Sums of yields 1933 *and* 1934.

lbs. leaf per 720 bushes.

	lbs. potash per acre			
	0	15	30	60
lbs. phosphoric acid per acre 0	2504	...	2689	2644
15	2638	2804	2719	2835
30	2579	2764	2712	2791
60	2644	2749	2837	2834
	Significant difference = 172			

Taking the two years together, we see either potash or phosphoric acid alone giving increased crop of about 4%, which is not quite significant, the higher doses doing no better than the lower.

All the nine combinations of potash and phosphoric acid with nitrogen give significant increases over nitrogen alone, averaging 11%; but there is no significant difference between the yields of any of the 9 plot-sets.

There is thus no advantage in using large doses of potash and phosphoric acid.

Considering only the 9 plot-sets receiving both potash and phosphoric acid we get the following averages :—

for 15 lbs.	potash	...	2,772 lbs. leaf.
,, 30 ,,	,,	...	2,756 ,, ,,
,, 60 ,,	,,	...	2,820 ,, ,,
,, 15 ,,	phosphoric acid	...	2,786 ,, ,,
,, 30 ,,	,, ,,	...	2,756 ,, ,,
,, 60 ,,	,, ,,	...	2,806 ,, ,,

As far as crop is concerned we can say that the mixture providing

40 lbs. nitrogen.
15 lbs. phosphoric acid.
15 lbs. potash.

is practically as good as any mixture providing higher quantities of phosphoric acid, potash, or both.

Leaf from a number of these plots was manufactured separately on 16 occasions in 1934. A full account of these experiments will be found in the Report of the Chemical Branch, p. .

There was so little agreement among the many tasters reporting, that significant differences in average valuations were not obtained; but the indications were (as last year) that the use of phosphoric acid as manure improved the teas, but that 30 lbs. phosphoric acid per acre was as good in this respect as 60 lbs. The effect of 15 lbs. phosphoric acid was not marked. With

respect to the effect of potash on quality, again differences were not significant, but the indications were that the use of heavy dressings of potash lowered quality.

Using the cheapest efficient forms, the cost of 40 lbs. nitrogen in Calcutta is about Rs. 10/-; that of 30 lbs. phosphoric acid about Rs. 5/-; that of the 20 lbs. potash about Rs. 3/-. On most soils the phosphoric acid and potash could be omitted without much loss either in crop or quality, and on many soils with no loss for some time.

The present (indefinite) indications are (on results both in 1933 and 1934) that the use of any potash tends to cause the good effect of phosphoric acid on quality to fail to appear. At present, therefore, potash should not be used on soils where its effect on crop is unlikely to be great. The effect even of the phosphoric acid is not distinct on quality, and is unlikely to appear at all on soils already containing ample phosphoric acid. The actual figures obtained at Borbhetta indicate the nature of the evidence.

	mds. tea per acre average 1933 and 1934	price of tea per lb. (average valuation of 4 London Brokers).	Annual cost of manure in Calcutta at present price.
No manure ...	8·42	1*s.*/1·13*d.*	*nil*
40 lbs. nitrogen only ...	12·16	1*s.*/1·13*d.*	Rs. 10/0/2
40 lbs. nitrogen with ... 30 lbs. phosphoric acid ...	12·53	1*s.*/1·38*d.*	Rs. 15/5/11
40 lbs. nitrogen with ... 30 lbs. phosphoric acid and 15 lbs. potash ...	13·43	1*s.*/1·15*d.*	Rs. 17/0/0
40 lbs. nitrogen with ... 30 lbs. phosphoric acid and 60 lbs. potash	13·97	1*s.*/0·76*d.*	Rs. 21/14/3
Significant difference for odds. of 20 to 1 ...	0·85	0·35*d.*	...

For Rs. 10/- annually we maintain over 3½ mds. more tea without loss in quality. The nitrogen was applied as sulphate of ammonia.

A further Rs. 5/5/9 gives us another 0.4 mds. tea with a possible increase in price of ¼*d.* a pound.

The complete manure costing Rs. 17/- has given 5 mds. more tea than from unmanured plots, without losing quality compared to unmanured tea.

Having regard to the high experimental error of the valuations, the indications in favour of phosphoric acid offer no more than a possibility. One of the four London Brokers however was definite in his opinions on the improvement in quality (not strength) due to phosphoric acid.

His average valuations were, on the 8 manufactures in August and September 1934 :—

No manure	...	11.91*d.*
40 lbs. nitrogen only	...	11.81*d.*
40 lbs. nitrogen and 30 lbs. phosphoric acid	...	12.56*d.*
40 lbs. nitrogen, 30 lbs. phosphoric acid and 15 lbs. potash	...	11.60*d.*
Significant difference	...	0.64*d.*

(2). The results from the Burma plots, where experiment was abandoned at the end of 1933, indicate that where larger dressings than 60 lbs. nitrogen per acre are used, potash and phosphoric acid must be increased above 30 lbs. of each.

Manure lbs. per acre.			Mds. tea per acre 1933.
Nitrogen.	Phos. acid.	Potash.	
60	30	30	16·32
60	60	60	16·32
90	30	30	16·61
90	90	90	18·75
120	30	30	18·35
120	120	120	20·66
	Significant difference ...		1·03

In the above cases manures were applied annually from 1924 to 1933 inclusive. Where 60 lbs. nitrogen per acre are used, 30 lbs. each of potash and phosphoric acid are sufficient to give full crop. When higher dressings than 60 lbs. nitrogen are used, 30 lbs. each of phosphoric and potash are not enough to enable the nitrogen to be fully used.

(3). In the case of Mesai-Manipuri plots (results from which are next recorded) the proportion nitrogen/phosphoric acid/potash = 2/1/1 is shown to be sufficient to give the full effect of the nitrogen on crop up to 80 lbs. nitrogen per acre at least.

NITROGEN.

(1). *The Mesai-Manipuri plots at Borbhetta.*

Continuous annual manuring 1930 to 1934.

Nitrogen as sulphate of ammonia in 1930, 1931, 1933 and 1934.

Nitrogen as calcium cyanamide in 1932.

It is intended to use cyanamide once and sulphate of ammonia twice, in every three years, in order to avoid complications due to change in soil acidity.

With each 2 lbs. nitrogen—

1 lb. phosphoric acid as superphosphate.
1 lb. potash as sulphate of potash (muriate in 1933).

Ten treatments each seven times repeated. Yields of all sets of seven plots each, practically equal in 1929, when the tea was eight years old from seed.

Over the three years, 1930 to 1932, the following results were obtained in mds. tea per acre :—

Plot-set.	Total lbs. nitrogen annually per acre	How applied.	Mds. tea per acre. 1930.	1931.	1932.	Total.	Average Total.	Gain.
1	nil	nil ...	7·53	8·19	6·09	21·81	21·81	
2	40	1 dose in March ...	9·59	10·30	9·32	29·21	29·48	7·6
3	40	20 lbs. in March .. / 20 lbs. in June ...	9·13	10·93	9·70	29·76		
4	80	1 dose in March ...	11·02	13·37	13·54	37·93	37·65	15·8
5	80	40 lbs. in March ... / 40 lbs. in May ..	10·92	13·51	13·06	37·49		
6	80	40 lbs. in March ... / 40 lbs. in June ...	10·92	13·23	13·09	37·24		
7	80	40 lbs. in March ... / 40 lbs. in July ...	11·09	13·45	13·41	37·95		
8	120	1 dose in March ...	12·44	15·56	16·00	44·00	34·72	21·9
9	120	60 lbs. in March ... / 60 lbs. in June ...	12·38	16·13	16·41	44·92		
10	120	40 lbs. in March ... / 40 lbs. in May ... / 40 lbs. in July ...	11·82	14·81	15·60	42·23		
		Significant difference ...	0·55	0·65	0·75			

It makes no significant difference whether manures are applied in one dose or in two or more; for the same total quantity of manure the same increase in crop is made. Neither does the date of application of the second dose make any difference. The only exception to this is 120 lbs. nitrogen in 3 doses which is slightly less efficient than in 1 or 2 doses.

The increases are roughly proportional to the quantity of nitrogen applied.

The cumulative effect of the manuring is marked. Increases in mds. tea per acre over no manure being :—

	1930.	1931.	1932.
40 lbs. nitrogen ...	1·83	2·42	3·42
80 „ „ ...	3·46	5·20	7·19
120 „ „ ...	4·68	7·31	9·92
Average per 40 lbs. nitrogen	1·66	2·49	3·42

The cumulative effect is ascribed mainly to increasing size of bushes.

In 1933 the following results were obtained :—

Plot-set.	Total lbs. nitrogen annually.	How applied.	Mds. tea per acre	Average.	Gain.
1	nil	nil ...	7·75	7·75	
2	40	1 dose in March ...	10·73		
3	40	20 lbs. in March ...	11·09	10·91	3·16
		20 lbs in June ...			
4	80	1 dose in March ...	14·52		
5	80	40 lbs. in March ...	14·26		
		40 lbs. in May ...			
6	80	40 lbs. in March ...	13·96	14·28	6·53
		40 lbs. in June ...			
7	80	40 lbs. in March ...	14·33		
		40 lbs. in July ...			
8	120	1 dose in March ...	15·53		
9	120	60 lbs. in March ...	16·85	16·17	8·42
		60 lbs. in June ...			
10	120	40 lbs. in March ...	16·13		
		40 lbs. in May ...			
		40 lbs. in June ...			
		Significant difference ...	0·78		

In the report for 1933 it was stated "Yields from the manured plots are much the same as last year, with one exception—plot-set No. 8, which now differs greatly in yield from the other two plot-sets (9 and 10) receiving also 120 lbs. nitrogen. The difference is greater than the calculated significant difference. Plot-sets 2 and 4 which also receive the whole of their manure in March have behaved normally. Plot-sets 9 and 10 which also receive a total of 120 lbs. nitrogen per acre have behaved normally. There is nothing to explain the relative failure of plot-set 8 in 1933 : no serious disease, for example, can be observed on any of its plots, although 5 of its seven plots show distinct drops compared to last year, while all other plots are about the same as last year, or gain a little. It is just possible that as much as 120 lbs. muriate of potash (instead of the sulphate) in one dose in spring might have caused some loss. The use of sulphate of potash will be resumed in 1934."

Results in 1934 have been :—

Plot-set.	Total lbs. nitrogen annually.	How applied.	Mds. tea per acre.	Average.	Gain due to Manuring.
1	nil.	nil ...	7·20	7·20	
2	40	1 dose in March ...	11·62	11·61	4·41
3	40	20 lbs. March, 20 lbs. June ...	11·64		
4	80	1 dose in March ...	16·19	15·83	8·63
5	80	40 lbs. March, 40 lbs. May ...	15·43		
6	80	40 lbs. March, 40 lbs. June ...	15·55		
7	80	40 lbs. March, 40 lbs. July ...	16·15		
8	120	1 dose in March ...	18·34	18·73	11·53
9	120	60 lbs March, 60 lbs. June ...	19·10		
10	120	40 lbs. March, 40 lbs. May ... 40 lbs. July	18·74		
		Significant difference ...	1·12		

Plot-set No. 8 in 1934 does not yield significantly less than the other two plot-sets 9 and 10 receiving 120 lbs. nitrogen. Plot-set 8 increased its crop by 2.81 mds. in 1934 compared to 1933, as against 2.25 mds. in the case of plot-set 9 which did so much the better of the two in 1933. The change from muriate to sulphate of potash is the most probable explanation.

It will be observed that the increases in crop per 40 lbs. nitrogen are :—

1st 40 lbs. ... 4.41 mds. tea per acre
2nd 40 lbs. ... 4.22 ,, ,, ,, ,,

Up to 80 lbs. nitrogen per acre the increase is practically proportional to the quantity of nitrogen applied.

The third increment of 40 lbs. nitrogen, however, gives only 2.90 mds. further increase, and therefore is not yielding results of as great economic value.

The 80-lbs. nitrogen-per-acre plots, giving 15 to 16 mds. tea per acre carry tea giving such efficient cover that very little cultivation is necessary, while no cultivation is necessary in the rains. There is little chance of further reduction in working costs by producing higher yields per acre than this.

A dose of 80 lbs. nitrogen per acre is therefore indicated as roughly the economic maximum for tea.

The possibility of reduced costs from producing the permissible crop from a reduced area of the *jats* of best quality, keeping the balance of the garden in reserve, makes it possible that such a dose may prove also to be somewhere near the economic minimum for tea, (see p. 106).

In 1935 leaf from these plots will be manufactured separately under properly controlled conditions.

It was established on other plots (p. 132) in 1934 that 60 lbs. nitrogen per acre, whether as artificial or organic, produced no lowering of quality : in fact, there were indications that teas from the artificially manured bushes were very slightly preferable. It is necessary to make sure that there is no falling off with 80 lbs. nitrogen and also to determine whether application in divided doses of large amounts is preferable for quality to application in single doses.

Different forms of Nitrogen Manure.

1. *Cattle manure.* (Part of Tingamira 9-acre block).

24 plots are used, divided into 6 blocks of 4 plots each, each block containing one of the four treatments. Plots were selected so that each set of 6 plots destined for different treatment had yielded alike in 1929 and 1930, all being unmanured in 1930. Manure at three different rates was applied in April 1931 to three of the plot-sets, the fourth being left unmanured. In 1932 no more manure was applied, but yields were recorded to determine the residual effect of the manuring of the previous year.

In March 1933 and 1934 manure was again applied to plot-sets 2 and 3, but not to plot-set 4. It is intended to leave plot-set 4, which received 20 tons cattle manure in 1931, unmanured until it ceases to show significantly greater crop than plot-set 1, which has not been manured.

The manure applied in 1931 was purchased from a neighbouring village and contained only 0.36% nitrogen. About 0.5% is nearer to the average of material usually collected from lines and villages. Fresh manure approaches 1% nitrogen. The sample used in 1931 looked fairly fresh, was not mixed with soil, and was normally dry (50% moisture). It is suspected to have been buffalo manure, which may be less rich than cow manure.

The yields recorded from the 1931 applications are therefore lower than usually would be obtained from dressings of equal weight. Results from the richer material used in 1933 and 1934 are better. The 1933 sample contained 0.54% nitrogen, and the 1934 sample 0.63%, though they were just as moist as the 1931 sample.

The following results were obtained in 1931 and 1932.

Cattle manure tons per acre 1931 only.	nitrogen lbs. per acre.	1931	1932	mds. tea per acre total	increase over no manure, in 2 years
nil	...	9·12	9·47	18·59	...
5	40	9·57	10·23	19·80	1·21 mds
10	80	10·10	10·58	20·68	2·09 „
20	160	11·20	11·66	22.86	4·27 „
		Significant difference for total of 2 years			1·08 „

With the very slow-acting cattle manure, as with the quick-acting sulphate of ammonia, crop increase is roughly proportional to the quantity of nitrogen applied. Cattle manure (as usually collected) commonly provides nearly as much phosphoric acid as nitrogen, and more than half as much potash. Hence it can be used alone, and still show proportionate effects.

It will be observed that in each case the effect is rather greater in 1932 than in 1931, although no manure was applied in 1932.

In 1933 and 1934 the following results were obtained :—

Cattle manure tons, per acre				mds. tea per acre		gain mds. tea per acre	
1931	1932	1933	1934	1933	1934	1933	1934
nil	nil	nil	nil	8·96	7·67	...	...
5	nil	5	5	10·57	10·33	1 62	2·66
10	nil	10	10	11·64	12·85	2·68	4·18
20	nil	nil	nil	10·58	9·30	1·62	1·63
Significant difference :—				0·70	0·64	0·70	0·64

The effect of the 20 tons of poor cattle manure applied in April 1931 is still showing strongly in 1934 : in fact the effect in 1934 is about three quarters as much as it was in 1931. The long-lasting property of cattle manure is thus established. For this reason its cumulative effect is great. The effect of the first application of 5 tons cattle manure in 1931 yielded a just measurable increase of 0.45 mds. tea per acre : after the third application the increase is 2.66 mds.

The three dressings of 10 tons cattle manure containing a total of 343 lbs. nitrogen have in 1934 produced just about as much crop increase as 3 dressings of sulphate of ammonia (applied at the same time) containing a total of 160 lbs. nitrogen, on the similar adjoining plots next reported on.

Up to the end of the first year of application, nitrogen as cattle manure had one quarter of the value of nitrogen as sulphate of ammonia. Up to the end of four years from the first application, cattle manure shows half the value of artificial nitrogen. In a still longer run the difference in efficiency may prove less.

Taking cattle manure as containing an average of ½% nitrogen, and sulphate of ammonia with 20.6% nitrogen at about Rs. 146/- per ton delivered and applied on an average garden; Rs. 146 ÷ 20.6 = about Rs. 7-1 per unit of nitrogen. On the basis of half the efficiency, cattle manure is worth about

Rs. 3-8-6 ÷ 2 = Rs. 1-12- per unit, for its nitrogen content alone. As far as the nitrogen is concerned therefore cattle manure is worth fully Rs. 8/12/- per 5 tons applied. A garden's own line manure often can be applied at about that rate—sometimes less—and it provides useful work in March and April when little other remunerative work is available.

In addition to the nitrogen, about 0.4% phosphoric acid and 0.3% potash are contained in average cattle manure. Assuming that in the long run these are as efficient as more readily available forms of phosphoric acid and potash, the two together would increase the value of the cattle manure by about Rs. 2-8/- per ton; but there is no information regarding the availability of phosphoric acid and potash in cattle manure as collected from lines or villages.

The possibility of improved quality from the use of cattle manure has been tested this year. Leaf from the plots getting 5 tons cattle manure annually and from the corresponding unmanured plots was separately manufactured on 16 occasions. Eight tasters agreed that there was no significant difference in quality between these two or between teas from the cattle manured plots and those manured with artificials on the adjoining similar plots next described : the cattle-manured teas being actually valued lowest of the lot.

2. *Artificial Manures.*

(*a*). Part of Tingamira 9-acre block at Borbhetta.

This experiment is on a block of tea immediately adjoining the cattle manure plots just described, and the tea on both was planted from the same nursery at the same time. The cattle manure experiments are on the better end of the land and were collar pruned in 1924, when this block was cut to 18″ only, but results from these two blocks are fairly closely comparable.

This experiment uses 49 plots divided into 7 blocks of 7 plots each, and each of the 7 different treatments occurs once in each block.

As explained last year on page 225 Annual Report all the manured plots received nitrogen at the rate of 40 lbs. per acre in 1931. They were left unmanured in 1932, to determine residual effects. In 1933 and 1934 all manures were applied to give 60 lbs. nitrogen per acre, in order to obtain larger differences for measurement.

Results in 1934 were :—

	Yields in lbs. leaf per 630 bushes.		
	1932	1934	
	unmanured preliminary	actual	adusted with 1932
Oilcake	773	904	917
Blood meal	810	997	987
Horn meal	798	1002	999
Nitrate of soda ...	802	986	981
Calcium cyanamide ...	791	1011	1013
Sulphate of ammonia ...	788	1043	1047
Significant difference ...	...	73	58

In 1934 oilcake yielded a significantly poorer crop than any other manure. Sulphate of ammonia yielded significantly better than nitrate of soda, as well as better than oilcake and Blood Meal.

With these exceptions, all the forms of nitrogen used are equal within experimental error.

The failure of the nitrate of soda to act as well as sulphate of ammonia this year, may be due to the excessively wet early season : or possibly the loss of tilth observed on other plots after long continued applications of about 200 lbs. nitrate of soda per acre, may be having some effect after application of about 400 lbs. only twice.

The yield from nitrate of soda however, is not significantly worse than from any other manure except sulphate of ammonia. The difference in favour of sulphate of ammonia is probably due to the particularly good effect of the sulphate of ammonia, perhaps associated with increasing soil acidity of the plots receiving this acid manure.

The actual yields obtained in 1934 in mds. tea per acre and the cost per acre of the manure applied in 1934 were as below :—

	mds. tea per acre	gain compared to no manure.	cost of 60 lbs. nitrogen together with 30 lbs. phosphoric acid and 30 lbs. potash, including freight at 12 as. per maund (at present prices).
No manure ...	6·58	...	...
Organic manures			
Oilcake ...	10·07	3·49	Rs. 34- * †
Blood meal ...	11·05	4·47	55-11
Horn meal ...	11·26	4·68	46- 8 †
Soluble artificials			
Nitrate of soda ...	10·98	4·40	40-6
Calcium Cyanamide	11·65	4·57	29-6
Sulphate of ammonia	11·61	5·03	28-14

* Oilcake purchased locally.

† In 1934 the natural contents of phosphoric acid and potash in these manures were taken into account, reduced quantities of artificial phosphate and potash being given.

Leaf from all these sets of plots, except those manured with nitrate of soda, was separately manufactured on 16 occasions during June, July, October and November. Valuations made no difference between the teas whether unmanured or manured with any of the five manures. Eight tasters agreed in this.

Full details of these experiments on quality will be found on page 14 of the Report of the Chemical Branch.

Long continued trials of organic manures against soluble artificials.

Each of these trials is repeated three times only on plots each of 1/50th acre, which in early years made the error of the experiment very high indeed. The differences in yield from the same treatment (which account for the "error") however are due mainly to differences in natural supplies of available nitrogen in the soil. As bigger crops are taken, the excess nitrogen of plots above the average becomes worked out, so that after a long time, plots under the same treatment tend towards equality, and the error of the experiment lessens.

From 1920 to 1930 all manured plots received nitrogen at the rate of 30 lbs. per acre.

By 1929 yields from the same treatment had become fairly alike, the average of 1929 and 1930 being :—

	mds. tea per acre.
No manure	5.09
Organic manures	
Nervox (sinews and hide)	5.73
Oilcake	6.80
Boga medeloa cuttings	7.53
Soluble artificials.	
Nitrate of soda	7.29
Sulphate of ammonia	7.26
Significant difference ...	0.97

The Nervox is giving significantly poorer results than the other manures, but the error of the experiment is still so high that there is no significant difference to be observed among the effects of the other four manures.

In 1931 and 1932, the rate of manuring was raised to 80 lbs. nitrogen per acre, partly to get bigger differences for measurement, and partly because it had been suggested that while such small doses of artificials might be used with safety, organic

manures might show better results than artificials when applied in large quantities.

Yields in 1932 were :—

No manure	...	... 4.69 mds.
Nervox	...	... 5·74 ,,
Oilcake	...	... 9.56 ,,
Boga medeloa cuttings		... 8.79 ,,
Nitrate of soda	...	... 7.11 ,,
Sulphate of ammonia		... 10.28 ,,
Significant difference		... 1.74 ,,

Within the still high calculated error, oilcake, boga medeloa cuttings and sulphate of ammonia yield equally well, being distinctly better than nitrate of soda or Nervox.

At the end of 1932 all plots were cut back to 18″ and no manure was applied in 1933, manuring of cut-back tea having been shown to be of little use. Yields in 1933 were small.

In March 1934 manuring was repeated as in 1931 and 1932.

Yields in quarter-pounds leaf per plot in 1934 were :—

	No manure	Nervox	Nitrate of soda	Oilcake	Boga medeloa cuttings.	Sulphate of ammonia	block totals
block 1	148	179	209	248	289	296	1369
,, 2	127	183	224	264	272	284	1354
,, 3	148	205	247	238	263	288	1389
treatment totals :—	423	567	680	750	824	868	

The differences between the block totals, which originally were great, have become negligible.

The calculated significant difference between treatment totals is 73.8 lbs.

The six treatments are thus definitely different in effect, except that sulphate of ammonia is not significantly better than boga medeloa cuttings.

Assuming that 100 lbs. leaf would give 22½ lbs. tea, the yields in mds. tea per acre are :—

	mds. tea per acre.
No manure ...	... 4.98
Nervox ...	... 6.64
Nitrate of soda ...	... 7.97
Oilcake ...	... 8.79
Boga medeloa cuttings ...	... 9.66
Sulphate of ammonia ...	... 10.17
Significant difference	... 0.86

The failure of the Nervox is attributed partly to the insoluble nature of its nitrogen compounds (sinews and hide), and partly to the bad effect on tilth of the gelatine it contains.

Nitrate of soda did very well in early years ; the loss of tilth on soils receiving it in these large and repeated doses is now very definite.

That oilcake does significantly worse than boga medeloa cuttings or sulphate of ammonia can only be attributed to the insoluble nature of some of its nitrogen compounds. Physical tests show no trace of loss of soil tilth.

The boga medeloa cuttings were all green and comprised very little woody material. The average nitrogen content of the undried material, as cut, has been about 1% and about 2½% in the dry matter. It has proved practically as readily available as the nitrogen in sulphate of ammonia. Such material clearly needs no pre-treatment before application to the soil.

In view of the interest lately shown in the Indore method of manufacturing "humus", this result is important. The Indore method of pre-treatment of woody material with a high ratio of carbon to nitrogen cannot be worth while on a specially grown leguminous crop with a low ratio of carbon to nitrogen, where pre-treatment must involve loss of nitrogen.

These plots are also of interest, in this same connection, in showing no advantage from addition of organic matter to the soil apart from the value of the nitrogen supplied.

Trial of Manures Containing Ammonia as Phosphate.

The Light-leaf Mesai-Plots at Borbhetta.

These consist of 54 small plots of only 1/50th acre each. As yields of individual plots varied very greatly, and were all very small, the area was divided into 9 blocks of 6 plots each, and only 6 trials conducted, each repeated 9 times.

In 1931 one plot-set was left unmanured and the other five used for trials of manures providing phosphoric acid in the form of phosphate of ammonia, nicifos and ammophos, against mixtures of sulphate of ammonia and superphosphate.

Sulphate of ammonia consists of 25.7% ammonia, the balance being sulphuric acid to keep it solid. The sulphuric acid sometimes has a value of its own, but not much, and generally it involves unnecessary freight. Superphosphate similarly contains 20% phosphoric acid; the balance being mainly lime in combination with it, and sulphate of lime, again, generally useless.

By combining the phosphoric acid with the ammonia, freight on the useless "carrier" is saved.

These modern materials also have advantages in reduced tendency to cake, and in not causing the containing bags to rot as superphosphate mixtures do. Thus an extra charge of Rs. 5/- per ton for double bags is saved, and the trouble of breaking up a caked mixture on arrival at the garden is saved, or at least greatly reduced.

It was shown in 1931 that all the mixtures were of exactly equal efficiency for the same quantity of nitrogen, whether sulphate of ammonia, ammophos or nicifos were used.

In 1932, and 1933 the trial was continued, using only one form of phosphate of ammonia (Nicifos), together with nitrate of potash, against the normal mixture of sulphate of ammonia,

superphosphate, and muriate of potash, but increasing the dressings in 1932 from 40 to 80 lbs. nitrogen on two of the plot-sets, and to 160 lbs. on another plot-set. In 1933 and 1934 all manured plots had only 40 lbs. nitrogen in the different forms.

The following have been the results :—

plot-set.	manuring lbs. nitrogen per acre.				phosphoric acid as	potash as	mds. tea per acre.		
	1931	1932	1933	1934			1932	1933	8934
1	nil	nil	nil	nil	...	...	4·71	5·59	5·37
2	40	40	40	40	nicifos	nitrate	6·85	8·26	9·27
3	40	40	40	40	super	muriate	6·52	8·08	8·86
4	40	80	40	40	nicifos	nitrate	7·44	8 90	9·65
5	40	80	40	40	super	muriate	7·88	9·36	9·91
6	40	160	40	40	nicifos	nitrate	9·14	10·64	11·09
					Significant difference :—		0·70	1·10	0·70

Comparison of plot-set 2 with 3, and of plot-set 4 with 5, shows that it makes no significant difference whether the potash is applied as nitrate or muriate, or whether the phosphoric acid is applied as superphosphate or nicifos.

	nicifos mixture	Superphosphate mixture
40 lbs. nitrogen in 1932 ...	9·27	8·86
80 ,, ,, ,, ,, ...	9·65	9·91
mean =	9·46	9·38
Difference required for significance between means = 0·49		

Effect of a Single Big Dose of Manure to Restore a Poor Area to Profitable Yield.

These same plots illustrate the possibilities in this direction. By 1930, complete starvation and over-plucking and over-pruning had brought these plots to a miserable condition. They had

always been well cultivated and cleanly pruned, and vacancies had been infilled annually, but the average yield of the whole block was below 5 mds. per acre.

In 1931, application of 40 lbs. nitrogen in various forms to 5 of the plot-sets brought yields up to 6¼ mds., still leaving miserable tea. Continuance annually of this moderate dose has brought yield to under 7 mds. in 1932, to 8 in 1933, and to 9 mds. in 1934. The tea is now a commercial proposition, but it has taken a long time to reach that state.

The more rapid effect of the bigger doses given in 1932 may be compared in the table below :—

Plot set	lbs. nitrogen per acre				mds. tea per acre		
	1931	1932	1933	1934	1932	1933	1934
1	0	0	0	0	4·71	5·59	5·37
2 and 3 average	40	40	40	40	6·68	8·17	9·06
4 and 5	40	80	40	40	7·66	9·13	9·78
6	40	160	40	40	9·14	10·64	11·09

The differences due to the bigger doses of soluble artificial applied in March 1932 are still significant in 1934, but naturally are becoming less now that all manured plots are receiving the same dressing of nitrogen. They are expected to approach the same yield as the same moderate annual dressing continues.

Trial of Green Crops.

Four treatments each 8 times replicated.

32 plots were divided into 8 blocks of four plots each. The four plots in each block received respectively the four following treatments in 1934, all having been treated alike to the end of 1933.

Plot-set	manure per acre, in 1934.	average mds. tea per acre	
		1933	1934
		(treated alike)	
1	No nitrogen	6·76	9·21
2	30 lbs. nitrogen as sulphate of ammonia ...	6·76	9·82
3	Cowpeas sown March 23rd hoed in May 23rd giving 5891 lbs. green stuff containing 27 lbs. nitrogen	6·79	9·23
4	Boga medeloa sown in alternate lines. Thinnings contained 3 lbs. nitrogen : loppings September 23rd contained 17 lbs. nitrogen. Total = 20 lbs. nitrogen	6·78	8·56
	Significant difference :— ...	...	0·32

Sulphate of ammonia. The small dressing of 150 lbs. sulphate of ammonia per acre has produced a gain in crop of 0.61 mds. tea or about 6½ %. This gain is very small for the quantity of nitrogen used.

This young tea (6 years from seed) on a good piece of soil has made a big increase in crop (due to increasing size of bushes) in 1934 over 1933. Under such conditions very little increased crop is commonly observed from additional nitrogen, and it must be assumed that the unmanured soil provided nearly as much nitrogen as the bushes could use.

It is clear therefore that the soil was relatively rich : yet the gain from the use of 30 lbs. nitrogen, only, in the form of sulphate of ammonia, is definitely significant; and if the green crops had provided additional nitrogen in anything like similar quantity, their effect on crop must have been shown, unless some countervailing adverse effect were in operation.

Boga medeloa. The boga medeloa plots have given 0.65 mds. less tea than the unmanured plots, and this loss is definitely significant.

In this case no significant quantity of nitrogen was got into the soil till September 23rd. Even assuming that the 17 lbs. nitrogen then added was a free gift from the air, the remainder of the season was barely long enough to allow much increase in tea crop to show up.

The monthly crops were in lbs. leaf per 672 bushes :—

	to end April	May	June	July	Aug.	Sept.	Oct.	Nov.
No manure ...	19·	26	104	120	145	212	177	83
Boga medeloa ...	17	24	99	111	137	189	172	84

The loss in crop from the use of boga medeloa shows in every month, although the loss in April and May cannot be said to be significant. The loss increases as the boga medeloa grows, till after the hoeing in of the loppings in September. In October the loss is greatly decreased, and there is no loss in November.

The losses over the season can only be ascribed to the normal harmful effect of any plant growing in the neighbourhood of another, mainly from the reduction of nitrification in the soil occupied, compared with clean soil.

A similar effect was observed with Arhar in 1925. These experiments were in conjunction with experiments on liming. Unlimed plots gave practically no crop of Arhar, and tea crop was the same as in the previous year, and the same as the similar untreated plots. With increasing dressings of lime, increasing crops of Rahar were obtained. 80 mds. crushed limestone per acre produced a huge crop of Rahar, and tea crop fell from 12 mds. to 8. The direct effect of the lime had been shown to be small.

The moderate crop of Arhar produced by 15 mds. crushed lime-stone per acre, caused a loss of tea crop of 1 md. per acre, but over the following three years there was a more than compensating gain of about 3 mds. Judging from the apparent good

effect of Boga medeloa in practice, a similar result is expected from these plots in the future. Meanwhile the definite loss from its use, this year, serves as a warning against allowing it to become too thick. Even young tea from which crop is not wanted, may receive a set-back from thick boga medeloa, from which recovery is difficult.

In 1935 the boga medeloa will be kept up and lopping continued. At the end of 1935 the remaining green parts will be buried. The heavy wood will be removed, without charge, by coolies short of firewood. In 1936 and following years the plots will be left unmanured to determine any residual effects.

Judging from effects apparent in practice, good results are expected.

Cowpeas. The effect of the growth of cowpeas in every line of tea was to give a crop exactly equal to the crop from the untreated plots.

Monthly crops were, in lbs. leaf per 672 bushes :—

	to end April	May	June	July	Aug.	Sept.	Oct.	Nov.
No manure ...	19	26	104	120	145	212	177	83
Cowpeas ...	19	25	103	124	151	211	172	82

The cowpeas were hoed in on May 23rd. The expected losses during the time of growth, and just after hoeing in, are only very faintly indicated. The very wet weather experienced over this period rendered the causes of loss (deficiency of soil moisture and accumulation of toxins in the soil) hardly operative. There are indications of gain in July and August after the cowpeas had rotted, but the gains are slight, and are offset by the losses in other months. The loss in October might be due to depletion of the soil of available nitrogen by organisms engaged in breaking down the more resistant carbon compounds.

The nett. result is neither loss nor gain from the use of cowpeas.

The cowpeas, when hoed in, contained 27 lbs. nitrogen per acre, practically as much as was supplied by the sulphate of ammonia which gave a significant gain.

The composition of the material hoed in was :—

	fresh material % of whole plant	nitrogen in fresh material %	water %	nitrogen % in dry matter.
leaf	43·16	0·622	81·08	3·309
stem	39·48	0·191	80·77	0·993
root	17·38	0·296	82·82	1·723
Average on whole plant ...	...	0·395	81·08	2·087

It is known that material as rich in nitrogen as this green crop provides readily available nitrogen. In explanation of the failure to produce increased crop, it can only be suggested that the nitrogen in the cowpeas represented at best a very small gain of nitrogen to the soil; but that the nitrogen had mainly been taken from the soil to which it was returned.

The roots of the cowpeas were well covered with nodules, but it is known that the presence of nodules does not necessarily imply the fixation of nitrogen from the atmosphere. In a rich soil the nodule organisims are merely parasitic on the plant.

In 1935, cowpeas will be sown again on these plots; climatic conditions may prove more favourable to them. The plots in following years will be left untreated to make sure that there is not some long-distance residual good effect.

Judging from effects to be observed in practice, there is little hope that such residual effect may prove significantly great.

Pending these final results it is advised that such crops as cowpeas be not used, in general. In very poor soils they probably will prove effective; but there appears little chance of maintaining any reasonably high level of fertility by their use. Their cost also is not small. Careful accounts were kept on these plots.

Cowpeas		Boga Medeloa (in 1st. year)		Artificial	
½ md. seed ...	Rs. 2/12	Collection of seed (5 seers).	Rs. 1/0	150 lbs. sulphate of ammonia @ Rs. 115/- per ton ...	Rs. 7-11
Freight and carting ...	-/6	Application of manure ...	-/4	Freight and carting ...	1- 6
Application of manure ...	-/8	Hoeing in of manure and preparation of seed bed in alternate lines ...	1/8	Application ...	0- 8
Hoeing in of manure and preparation of seed bed in every line	3/0	Sowing and covering of seed ...	1/4		Rs. 9/9
Sowing and covering of seed ...	2/8	Thinning ...	1/8		
Extra cost of burial of cowpeas above ordinary light hoe.	3/0	Lopping ...	2/0		
	Rs. 12/2		Rs. 7/8		

At Borbhetta, the cost of the phosphate and potash manure (Rs. 6/11/-) ought also to be charged against the cowpeas, since without it the crop of cowpeas would have been negligibly small, and it is unnecessary for the tea. However this would not always be true, and in this case all plots did receive the same amounts of potash and phosphate.

EXPERIMENTAL PLOTS AT TULSIPARA (Dooars).

Cultivation.

40 plots of 200 bushes each, divided into 10 blocks of 4 plots each.

The four plots in each block have received the four different systems of light cultivation, described, since December 1930. Five of the 10 blocks get a deep hoe every January in addition; the other 5 blocks get no cold-weather cultivation at all or any cultivation other than that described as "light cultivation."

Average yields in mds. tea per acre 1934.

plot-set.	light cultivation	averages of 5 plots		averages of 10 plots with and without deep hoe.
		with deep hoe	without deep hoe	
1 and 1a.	8 light hoes at monthly intervals, March to Oct. ...	11·21	10·62	10·91
2 and 2a.	8 rounds "cheeling" at same times as 1 and 1a. ...	11·52	10·84	11·18
3 and 3a.	4 light hoes, March, May July and August. ...	9·62	9·46	9·54
4 and 4a.	4 rounds sickling at same times as light hoeing in 3 and 3a.	9·34	9·59	9·46
	Average of 20 plots ...	10·42	10·13	...
	Significant difference between averages of 10 plots.	...	... =	1·34 mds.

It makes no difference whether the 8 rounds of cultivation are by light hoeing which stirs the soil to a depth of several inches, or whether jungle is suppressed merely by scraping (or "cheeling") the surface, without disturbing the soil at all.

Both these forms of cultivation however yield significantly better results than either light hoeing or sickling only four times annually.

It makes no significant difference whether the land is sickled or hoed, when both operations are performed only four times annually.

With regard to the difference produced by deep hoeing; the difference required, for odds of 20 to 1 on significance, between means of 20 plots is 0.95 mds. The apparent difference in favour of deep hoeing of 0.29 mds. tea per acre therefore has no significance.

It may appear surprising that plot-set "4" getting 4 rounds of sickling only, so that the soil is never disturbed at all, should yield as well as plot-set 3 getting 4 rounds of light hoeing and a deep hoe in addition. Both however get about equally weedy, and, both at Tulsipara and at Borbhetta, it is clearly apparent that the amount and character of the weeds present are the controlling factors regulating crop response to cultivation.

Trials of trenching in conjunction with cattle manure.

6 × 6 Latin square, with preliminary records from all 36 plots treated alike in 1933.

Preliminary yields in lbs. leaf per total of 6 plots (1,200 bushes) with all plots treated alike, in 1933, were :—

treatment in 1934	ordinary deep hoe	V-shaped trench in every row 9″ deep	rectangular trench in alternate rows 18″ deep	averages with and without manure.
No manure ...	1646	1603	1575	1608
10 tons cattle manure per acre	1624	1638	1609	1624
average for cultivation treatments	1635	1620	1592	...

Actual yields of leaf in 1934 when the different treatments were applied were :—

treatment	ordinary deep hoe	V-shaped trench in every row 9″ deep	rectangular trench in alternate rows 18″ deep	averages with and without manure
No manure ...	2467	2397	2349	2404
10 tons cattle manure per acre	2485	2379	2433	2432
average for cultivation treatments	2476	2388	2391	...

The preliminary yields of 1933 were not quite equal. Using the analysis of co-variance, the yields for 1934 after adjustment with those of 1933 are :—

treatment	Adjusted yields 1934. ordinary deep hoe	V-shaped trench in every row, 9″ deep.	rectangular trench in alternate rows, 18″ deep.	averages with and without manure.
No manure ...	2435	2408	2388	2410
10 tons cattle manure per acre	2475	2355	2438	2423
Averages for cultivation treatments	2455	2382	2413	
difference required for singificance ...		117		difference required for significance 95

There are no significant differences, either due to manuring, or due to the difference in cold-weather cultivation. The

experiment has proved a very accurate one which would have showed quite small differences to be significant.

It will be observed that all plots have yielded an increased crop in 1934 compared to 1933 of about 50%. Under such circumstances it is very difficult to measure any such small difference as might have been caused by the difference in manuring or cultivation.

The great increase in 1934 does not, in this case, appear to be attributable to a specially favourable season. The other plots at Tulsipara, which have been under experiment longer, have yielded in 1934 much about the same as in 1933, or a very little more.

It does not appear to be connected with either the regularity or the severity of the plucking. These plots now under consideration were plucked weekly, and exactly similarly, in 1933 and 1934 : and the results of plucking experiments show only small differences to be due to plucking in any case.

It does not appear to be connected with either the regularity or the manner of the cultivation. In the set of experiments last considered it is shown how little cultivation counts, among good bushes : and these plots now under consideration carry very good bushes indeed—the average yield in 1934 was over 14 mds. tea per acre.

The pruning experiments show the highest yields (up to 4 years of continuous treatment) to be obtained from the cheapest possible pruning without cleaning out. We cannot claim any advantage from improved pruning within the first two years of experiment.

This sudden increase in crop, after a set of plots is put under experiment, is a very common feature of experiments on commercial gardens, and the explanation of it is still to be sought. Such increases appear too frequent, and too great, to be assigned to pure chance.

In the meantime it is clear that no advantage has yet been obtained from either expensive method of trenching. In future years the plots will be treated all alike to discover whether any advantage shows up eventually.

MANURING EXPERIMENTS.

(1). *Trial of cattle manure against equivalent artificial.*

Plot-set (*a*). 5 tons cattle manure annually.

Plot-set (*b*). Artificial supplying quantities of nitrogen, phosphoric acid and potash equal to that found in the cattle manure averaging about 60 lbs. nitrogen annually.

Plot-set (*c*). No manure.

The treatments are replicated three times only, on three blocks of three plots each. The results of manuring have been small and were not sufficiently great to show any differences of any significance at all until 1934. All plots were plucked unmanured in 1930.

plot-set	manure 1931 to 1934	yields in mds. tea per acre		
		all unmanured	manured	
		1930	1933	1934
a	cattle manure ...	5·90	13·12	14·39
b	artificial	5·70	13·15	14·44
c	no manure	5·94	12·23	12·88
	Significant difference :—	...	...	1·60

Both manured sets plots now yield increases on the verge of significance, but the increases are very small for the amount of food given.

(2). *Big Manuring block* (4th year of continuous treatment).

9 treatments repeated 6 times in 6 blocks.

All manures as soluble artificials.

The yields in 1934 were :—

plot-set	lbs. per acre annually 1931 to 1934			yield 1934 mds. tea per acre	average
	nitrogen	phos : acid	potash		
1	nil	nil	nil	11·68	11·68
2	40	0	0	12·34	
3	40	0	40	14·00	
4	40	0	80	13·85	13·29
5	40	40	0	12·97	
6	40	40	40	13·21	
7	80	0	0	14·93	
8	80	0	80	14·29	14·66
9	80	0	160	14·75	
		Significant difference =		1·48 (for odds of 20 : 1 on significance).	

The evidence regarding potash and phosphoric acid is still indefinite. With only 40 lbs. nitrogen, the use of either 40 or 80 lbs. potash appears to show a significant increase compared to nitrogen alone : but no improvement appears from the use of potash when 80 lbs. nitrogen per acre are used. No significant improvement appears from the use of phosphoric acid, either in plot-set 5 against 2, or in plot-set 6 against 3.

The effect of nitrogen is distinct, but still very small : the unmanured plots are still yielding very well and show no sign of serious food-shortage.

PLUCKING.

Nine different systems of plucking each repeated in each of 7 blocks.

In 1930 all plots were plucked alike for preliminary record. Plots were then divided up so that all 9 plot-sets of 7 plots each had yielded practically alike in 1930. The different systems of plucking were applied from 1931 unwards.

In 1931 very small crops were obtained on account of very bad mosquito attack and differences in crop due to plucking were negligible. Over the past 3 years crops have been :—

plot-set.	style of plucking.	1932	1933	1934
	Weekly plucking.			
1.	6″ to janam	9·04	13·24	13·92
2.	8″ ,, ,, ...	7·92	12·58	13·58
3.	6″ then 1 leaf (once only) then janam ...	8·04	12·74	13·92
4.	6″ ,, ,, till mid-August then janam ...	8·09	11·50	11·62 (12·05)
5.	8″ ,, ,, (once only) then janam ...	7·26	11·65	12·63
6.	4″ leaving janam and big leaf at each plucking throughout season	7·29	9·62	0·57
	plucking at different intervals all plucked 6″ to janam except when not broken back.			
1.	6″ to janam weekly, with breaking back ...	9·04	13·24	13·92
7.	6″ ,, ,, at 10 days' interval breaking back	9·75	13·25	14·53
8.	6″ ,, ,, ,, 10 ,, ,, without breaking back ...	9·91	12·39	13·67
9.	6″ ,, ,, ,, 14 ,, ,, ,, ...	7·81	11 39	11·99
	Significant difference ...	0·76	0·47	0 99

Weekly plucking.—In 1934 there is no significant difference in crop whether the bushes are plucked at 6″ to the janam, 8″ to the janam, or at 6″ and then a leaf left once only. Any less severe style of plucking than these still gives significantly reduced crop.

The yield of plot-set 4, (6″ and then a leaf till mid-August) is recorded as weighed. On one of the seven plots, however, a patch comprising one quarter of the bushes died from a root disease and yielded nothing in 1934. It is difficult to adjust yields to allow for such accidents, but approximately 1/27″ of the yield recorded should be added and this "adjusted" yield is placed in the table above in brackets (12.05 instead of 11.62). Even

with this adjustment, however, yield is clearly reduced, by continually leaving leaves for so long as up to mid-August, as well as on plot-set 6 where a leaf is left throughout the season.

Plucking at different intervals.

All plucked to janam, except where breaking back is not done.

interval between pluckings.	1932	1933	1934	Total
7 days with breaking back ...	9·04	13·24	13·92	36·20
10 days „ „ „ ...	9·75	13·25	14·53	37·53
10 days without „ „ ...	9·91	12·39	13·67	35·97
14 days „ „ „ ...	7·88	11·39	11·99	31·26

Results are irregular. It is extremely difficult to maintain anything like the same standard of fineness of the leaf plucked, when plucking at different intervals. Even with the greatest care in supervision, the leaf taken at longer intervals must be somewhat coarser than that taken at shorter intervals.

The additional time wasted in breaking back has not produced a crop increase commensurate with the increased cost.

Extending the interval between pluckings to 14 days, does result in significantly reduced crop.

At times when quality is produced labour is abundant, and there is no reason why plucking should not be carried on without risk to quality.

During the rains, when labour is deficient, and Tocklai results show little price increase from increased fineness of plucking, the above results may be used to cheapen plucking with little risk in any district.

Plucking at 10 days' interval without wasting time in breaking back has produced as great a crop as plucking at 7 days' interval, with breaking back; and on the 1934 market at any rate, the difference in quality probably was almost negligible.

PRUNING.

Nine treatments repeated seven times in seven blocks.

All plots treated alike in 1930.

Different treatment applied

1931, 1932, 1933 and 1934.

Yields were very small in 1931 on account of very bad mosquito blight, which has since been present to such small extent that its effect on crop has been practically negligible and crops over the past two years have been remarkably heavy, having regard to the stony nature of the soil on this area.

The effect on the bush of difference in severity of attack caused by difference in pruning in 1931, however, may have persisted in later years.

The following yields have been obtained.

plot-set.	pruning.	mds. tea per acre			
		1931	1932	1933	1934
1.	annually pruned December with cleaning out	2 96	7·27	11·26	10·94
2.	pruned in alternate years December, with cleaning out	2·96	8·49	10 93	13·33
3.	annually pruned December, without cleaning out	3·37	6·88	9·96	10·74
4.	pruned in alternate years December, without cleaning out	3·37	9·23	10 00	15·57
5.	stick pruned January 1931, then lightly cleaned out, December, annually...	2·04	5·80	10·16	9 51
6.	stick pruned January 1931, then pruned in December, (with light cleaning out) in alternate years ...	2·04	7·41	9·55	12·93
7.	pruned early April (with cleaning out) annually	2·45	5·39	9·82	8 45
8.	pruned early April (with cleaning out) in alternate years	2·45	10·37	9·62	15·39
9.	pruned (with cleaning out) June 1931, December 1932, June 1934 ...	4 34	9·33	11·22	7·37
	Significant difference ...	...	...	1·09	1 30

(a). The use of unpruned tea.

In the portion of the report dealing with results at Tocklai it was shown that though the use of unpruned tea gave increased crops compared to pruned tea for a few years, yet unpruned tea over a large number of years has shown decreased crops, and that in later years less crop has been obtained when the tea is unpruned than when it is pruned.

At Tulsipara to-date (over four years) the use of unpruned tea has shown very great profits, and there is, as yet, no sign of consequent deterioration of the bushes.

We have 4 pairs of comparisons to consider.

(i). Pruned in December with cleaning out.

	1931	1932	1933	1934	Total
Pruned annually	2·96	7·27	11·26	10·94	32·43
Pruned December 1930, and 1932 only	2·96	8·49	10·93	13·33	35·71

There is a negligibly small drop in 1933 when plucking after cutting on two-year old wood, and substantial gains in 1932 and 1934 when plucking unpruned compared to plucking after light pruning.

(ii). Pruned in December without cleaning out.

	1931	1932	1933	1934	Total
Pruned annually	3·37	6·88	9·96	10·74	30·95
Pruned December 1930 and 1932 only	3 37	9·23	10·00	15·57	39·17

Results are similar, but as annually pruned tea gives less crop if not cleaned out, while unpruned tea gives more if not cleaned out, the difference in favour of leaving unpruned is greater.

(iii). Pruned early April with cleaning out.

	1931	1932	1933	1934	Total
Pruned annually	2·45	5·39	9·82	8·45	26·11
Pruned April 1931 and 1933 ...	2·45	10·37	9·67	15·39	37·88

Here again there was practically no loss in 1933 when both sets were pruned, one on two-year-old and one on one-year-old wood, and there are very big gains when the tea is unpruned.

We get our biggest gains from leaving unpruned when pruning is late : this is because tea pruned annually, late, never gets a full season of growth.

(iv). Stick pruned January, 1931.

	1931	1932	1933	1934	Total.
Lightly cleaned out December 1931-32, 1933	2·04	5·80	10·16	9·51	27·51
Lightly cleaned out December 1932 only...	2·04	7·41	9·55	12·93	31·93

Here again there is a very small loss after cutting on two year wood in 1933 and a substantial gain in the following year left unpruned.

In all these four comparisons the gain from leaving unpruned in alternate years is very significant. It remains to be seen whether this gain will last over many years, but the certainty of immediate gain is valuable.

(b). Pruning at 18-month intervals.

Plot-set 9, pruned in June 1931, December 1932, and June 1934 may be compared with annual pruning over two sets of 3 years, 1931-33, and 1932-34.

	1931	1932	1933	Total.
Annual pruning, December with cleaning out	2·96	7·27	11·26	21·49
Pruned June 1931 and December 1932 ...	4·34	9·33	11·22	24·89

In 1931, being plucked unpruned until pruned in June, before mosquito attack was severe, the June-pruned plots did well compared to annually pruned plots. They were very severely attacked by mosquito after pruning and yielded practically nothing for the rest of the season, but the annually pruned plots also yielded little in that latter half of the season.

In 1932 when plucked unpruned the plots pruned in June 1931 yielded a good increase over annually pruned plots. In 1933 after pruning on 18-months-old wood they gave the same crop as the annually pruned plots pruned on one-year wood.

Over these three years, then, the June pruning shows advantage over annual pruning.

Over the next set of three normal years such advantage is not seen.

	1932	1933	1934	Total
Annually pruned December	7·27	11·26	10·94	29·47
Pruned December 1932 and June 1934 ...	9·33	11·22	7·37	27·92

When pruning in a normal year (1934) the loss of crop after pruning in June, more than counterbalances the gain from leaving unpruned in 1932.

On the present evidence, pruning in alternate years looks likely to suit Tulsipara best.

(c). *Time of pruning.*

The influence of time of pruning is best observed by considering monthly crops.

plot-set.		Monthly crops 1934									
		March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total.
	unpruned in 1934.										
8.	pruned April 1931 and April 1933.	1·30	1·51	1·30	1·74	3·04	2·71	2·22	1·39	0·17	15·39
2.	pruned Dec. 1930 and Dec. 1932	1·40	1·26	1·02	1·36	2·53	2·35	2·02	1·15	0·15	13·33
	pruned in 1934.										
9.	pruned Dec. 1932 and June 1933.	1·43	1·34	0·97	1·26	0	0·52	0·70	1·02	0·12	7·37
7.	pruned April annually.	1·34	1·04	0	0·22	1·04	1·70	1·75	1·22	0·13	8·45
1.	pruned Dec. annually.	0·02	0·23	0·50	1·32	2·32	2·47	2·26	1·56	0·16	10·94

The first four sets of plots all start the season unpruned and in March all yield about the same big crop compared to the pruned tea. In March the biggest crop is yielded by the tea farthest from its last pruning but there is not much in it.

From April onwards the tea last pruned in April 1933 gains definitely on the tea last pruned in December 1932, and this tea pruned in April 1933 does not fall behind the tea pruned in December 1933 until October 1934, and then the loss is slight.

The tea last pruned in December 1932 falls behind the annually pruned tea in August 1934, but the loss is not marked till October. We do not, at Tulsipara, get the big flushes from June onwards that we see at Borbhetta from annually pruned tea compared to unpruned tea.

The tea pruned in June 1934 does about as well as the other set also last pruned in December 1932, until the pruning on June 20th. Following the pruning it was not tipped till August 14th, and the bushes filled up very slowly after that.

The tea pruned in April annually also yielded much the same as other sets starting the season unpruned until after pruning on April 11th. From then it was not tipped till June 12th and the bushes were not as well filled up as the tea annually pruned in December even by the end of the season.

It is considered, on the evidence, that where annual pruning is to be practised, pruning should be as early as possible, as is found at Borbhetta. Where tea is to be left unpruned in alternate years, there appears no objection to late pruning : in the following year, when unpruned, the tea has a chance to make up the loss which is bound to occur from late pruning in the year when the tea is pruned.

	Mds. tea per acre.		
	1933	1934	Total.
Pruned April 1933, unpruned 1934 ...	9·67	15·39	25·06
Pruned December 1932 unpruned 1934 ...	10·93	13·33	24·26

The difference in total in favour of April pruning is not definitely significant, but there are other advantages in April pruning.

One makes sure of the big first flush of late March and early April every year, before mosquito attacks. The indications in 1931 also were that later pruned tea was less attacked. The autumnal crops also are greater in the unpruned year, and not significantly less in the pruned year. The objection to delaying pruning till after the first flush, over too great an area is the concentration of the crop over a very short period. The

sum of the last plucking in March and the first plucking of April may be as much as one fifth of the whole crop for the season from unpruned tea in a good year.

The second flush teas of course are lost by pruning in April, and late pruning can never be recommended where second flush teas are of importance.

(*d*). *Effect of light cleaning-out.*

(*i*). *December pruning with annual light cleaning-out.*

	Monthly crops 1934.									
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total.
Cleaned out annually	·02	·23	·50	1·31	2·32	2·47	2·26	1·56	0·25	10·94
Not cleaned out	·01	·10	·27	1·22	2·20	2·50	2·35	1·81	0·29	10·74

As at Borbhetta the cleaned out tea shows heavy gains in the early part of the season; but, as was not observed at Borbhetta in the earlier years of the experiment, the tea not-cleaned-out goes ahead (in 1934) after the end of July, and at the end of the season there is no significant difference in crop whether the tea is cleaned out or not.

Crops over the last 3 years have been :—

	Cleaned out.	Not cleaned out.
1932	7·27	6·88
1933	11·26	9·96
1934	10·94	10·74
Total ...	29·47	27·58

The total gain to date from cleaning out hardly repays the cost of the operation. It remains to be seen whether, in the long run, the more sanitary condition of the cleaned-out bushes will affect crop greatly.

(ii). Light cleaning out of tea pruned in alternate years.

	December pruning.				
	1931	1932	1933	1934	Total.
Cleaned out	2·96	8·49	10·93	13·33	35·71
Not cleaned out ...	3·37	9·27	10·00	15·57	38·21

In 1931 crop was reduced by mosquito blight attack. In that year although the cleaned out tea started the better, it was quite clear that it was much the worse attacked by mosquito, and finished the season in much the more rotted condition. This may have accounted for its poorer yield in 1932 when unpruned. In 1933 the cleaned out tea made its normal better start, and mosquito being practically absent kept its lead sufficiently long to make a significant gain in total crop for the season.

From the start of season 1934, and in complete absence of mosquito till very late in the season, the tea not cleaned-out went ahead of that cleaned-out. It is considered therefore that where tea is to be left unpruned in alternate years it does not pay to clean it out in the Dooars; while, where mosquito is likely to attack, it will be better not to clean out at all as far as removal of leaf-bearing twigs is concerned, though removal of diseased and dead wood probably may pay in the long run.

Up to the end of four years of treatment, the cheapest possible type of pruning has paid not only in reduced cost, but actually in giving larger crops : that is to cut-across at intervals of two years without any cleaning out. Where, also, tea is to be pruned in alternate years, there is no object in hurrying the pruning, but the work can be spread out as convenience requires.

(iii). Stick pruning.

The bushes at Tulsipara in 1930 appeared very congested, and it was thought that drastic cleaning out might do good here, if anywhere.

Two sets of 7 plots each were therefore stick-pruned and lightly centred at the end of season 1930.

One set has since been lightly cleaned out annually, the other in alternate years only. Each may be compared with the corresponding set of plots only lightly cleaned out at the end of 1930.

	mds. tea per acre				
	1931	1932	1933	1934	totals
Annually pruned tea					
lightly cleaned out end 1930, 1931, 1932, 1933	2·96	7·27	11·26	10·94	32·43
stick-pruned end 1930, lightly cleaned out end 1931, 1932 and 1933	2·04	5·80	10·16	9·51	27·51
tea pruned in alternate years					
lightly cleaned out end 1930 and 1932 ...	2·96	8·49	10·93	13·33	35·71
stick-pruned end 1930, lightly cleaned out end 1932	2·04	7·41	9·55	12·93	31·93

Both with annual and with alternate-year pruning there are significant losses over the four years following the stick pruning.

The stick-pruned bushes have still distinctly less spread. They do now carry the better looking wood; but until this advantage is reflected in crop increase, it cannot be considered of importance, and the stick-pruning must be considered an expensive failure. In this respect it is expected that similar results would be obtained in districts other than the Dooars.

SPRAYING (with lime sulphur).

Old Spraying plots.

Three treatments each ten times repeated.

It having been shown over the three previous years that no good effect was produced by spraying in the cold weather after pruning, this cold weather spraying was given up, and these plots used for trial of a weaker solution of lime sulphur.

Results in 1934 were :—

	mds. tea per acre.
No spraying	12.00
Spraying with weak solution (1 in 24) in April	12.70
Spraying with strong solution (1 in 12) in April	12.98
Significant difference ...	0.96

The effect of the strong spraying is just significant, but it is almost negligibly small, from a practical standpoint. Within the error of the experiment, the weak solution is as effective as the strong solution. It might not have proved so if the slight attack of red spider had not disappeared quickly even on the untreated plots.

In 1934 the red spider attack was almost unnoticeable.

Results from the strong spraying over the three years of treatment have varied with the degree of attack by red spider.

	very bad red spider 1932	fairly bad red spider 1933	red spider attack practically negligible 1934
unsprayed ...	5·38	12·08	12·00
sprayed	7·69	13·95	12·98
gain mds. tea per acre ...	2·31	1·87	0·98
gain per cent ...	43	15	8

It can only be concluded that spraying (in April, just after the first flush) is extremely valuable, when red spider attack is at all bad; but that in the absence of red spider, no remunerative good effect is obtained, at any rate at Tulsipara, although the plots used for the trial have quite the usual amount of fungus diseases present.

As in previous years, crop was depressed for four weeks after the spraying, after which a more than compensating gain is observed. Both the depression in crop and the following gain are greater with the strong solution than with the weak solution.

lbs. leaf per 2000 bushes.

	to April 12th. (before spraying)	April 20th. to May 11th.	May 11th. to June 29th.	July 6th. to November 30th.
unsprayed ...	63	71	552	2745
weak solution ...	62	49	631	2889
strong solution ...	62	35	650	2964

2. *New Spraying Plots.*

Seven different treatments, each nine times repeated.

Plan of experiment, randomized blocks without preliminary yields.

The experiment commenced in 1933, and the same treatments were repeated in 1934. Actual yields obtained were :—

mds. tea per acre, 1934.

Plot-set 1.	No spraying	13·13
,, 2.	Sprayed in April (strong solution).	12·72
,, 3.	Sprayed in April (strong solution) and in July and September (week solution)	14·36
,, 4.	Sprayed in July (weak solution) ...	12·49
,, 5.	Sprayed in July (strong solution)	12·85
,, 6.	Sprayed in September (weak solution)	12·02
,, 7.	Sprayed in September (strong solution)	12·61

Although the tea on the whole is now good, the variation, between yields of individual plots, is so great that none of the treatments produce yields significantly different from that of the untreated plot-set 1.

When however the weekly yields are plotted as graphs for comparisons, it is quite clear that the spraying did affect crop over certain periods. These graphs are hardly worth reproduction. The effects can be noted sufficiently clearly in the total yields over the periods during which these effects showed.

Plot-set.	Spraying	Actual crops in lbs. leaf per 1800 bushes in different periods.								
		to Apr. 14th, before spraying.	Apr. 21st to May 12th, after spraying	May 19 to June 30th.	July 7 to July 30th.	July 18 to Aug. 11	Aug. 18 to Sept. 1	Sept. 8th. to Sept. 22nd	Sept. 29th. to Oct. 20th.	Oct.. 17th to Dec. 1st.
1.	None	59	85	545	396	460	442	505	582	314
2.	April, strong	61	60	598	409	453	442	490	547	249
3.	April, strong; July, weak	65	64	611	387	546	464	459	773	335
4.	July, weak	56	72	501	342	500	419	492	553	286
5.	July, strong	59	79	527	278	596	424	524	550	279
6.	Sept. weak	51	72	501	362	403	391	373	658	289
7.	Sept. strong	54	75	511	376	423	408	353	747	307
		neutral period before any spraying.	period of depression after April spraying	period of big increase due to April spraying.	period of depression due to July spraying.	period of big increase due to July spraying.	neutral period	period of depression due to Sept. spraying.	period of big increase due to Sept. spraying.	neutral period

On these same plots in 1933 the yields of tippings before the spraying in April were sufficiently large to serve as indices of the relative initial fertilities of the various plot-sets, and yields in later periods were found to be closely correlated with them. In 1934 no close correlation with later yields exists, and the crops to April 14th are of no value as preliminary records.

Five of the plot-sets, however, were all treated alike to the end of June, and these yields to the end of June do prove to be closely correlated with later yields, and yields in later periods therefore can be adjusted, using the analysis of variance.

plot-set.	spraying.	adjusted yields in lbs. leaf per 1800 bushes.					
		July 7th. to July 21st	July 28th. to Aug. 11th.	Aug. 18th. to Sept. 1st.	Sept. 8th to Sept. 22nd.	Sept. 29th. to Oct. 20th.	Oct. 27th. to Dec. 1st.
1.	nil ...	376	439	420	478	553	280
3.	July 1st. weak.	351	511	431	505	566	302
4.	July 1st. strong.	271	588	416	513	541	267
5.	Sept. 1st. weak.	375	416	403	387	675	309
6.	Sept. 1st. strong.	380	428	412	358	753	305
	Significant difference :—	17·8	30·5	...	45·5	46·2	...

As in 1933 therefore it is clearly shown that each spraying was followed by a few weeks of significantly reduced crop, and this period was followed by another few weeks during which the loss was made up.

On balance there was no significant difference over the whole season either in gain or in loss from spraying.

Taking the total yields after the end of June (after spraying in July) and adjusting them with the yields before the end of June (before spraying) we get :—

adjusted yields July 1st. to December 1st. in lbs. leaf per 1800 bushes.

No spraying	2581
Sprayed July, weak solution	2650
,, ,, strong ,, ...	2614
,, Sept. weak ,, ...	2552
,, ,, strong ,, ...	2644

The calculated difference which would be required for significance is 327, so that none of the differences between the above approach anywhere near to significance, and the spraying must be judged to have been without effect.

EXPERIMENTS AT HALEM TEA ESTATE.

These experiments compare the relative values of cattle manure at 200 mds. per acre, supplying over 100 lbs. nitrogen, 80 lbs. phosphoric acid and 60 lbs. potash, and an artificial mixture supplying 40 lbs. nitrogen, 20 lbs. phosphoric acid, and 20 lbs. potash per acre against no manure.

Full details of the experiment were given in last year's report p. 267. Each treatment is five times replicated, enabling an estimate to be made of the error to which the averages are liable.

The results have been :—

	Mds. tea per acre	
	1933	1934
Cattle manure	10·46	11·17
Artificial	10·52	11·53
No manure	9·83	10·30
Significant difference	0·72	0·69

In 1933 neither manure had given an increase over "no manure" which could be considered definitely significant. The further applications of manure in 1934 have raised the increases so that they are now definitely significant. The apparent superiority of the artificial over the cattle manure is not significant.

The actual costs of the two applications per acre at Halem were :—

16,000 lbs. cattle manure including collection, carting and application ... } Rs. 8-2.

340 lbs. artificial mixture including freight, carting and application ... } Rs. 15-0.

At these prices the cattle manure, so far, appears much the better value, but cattle manure cannot often be obtained either as cheaply or in as great quantity as it is at Halem.